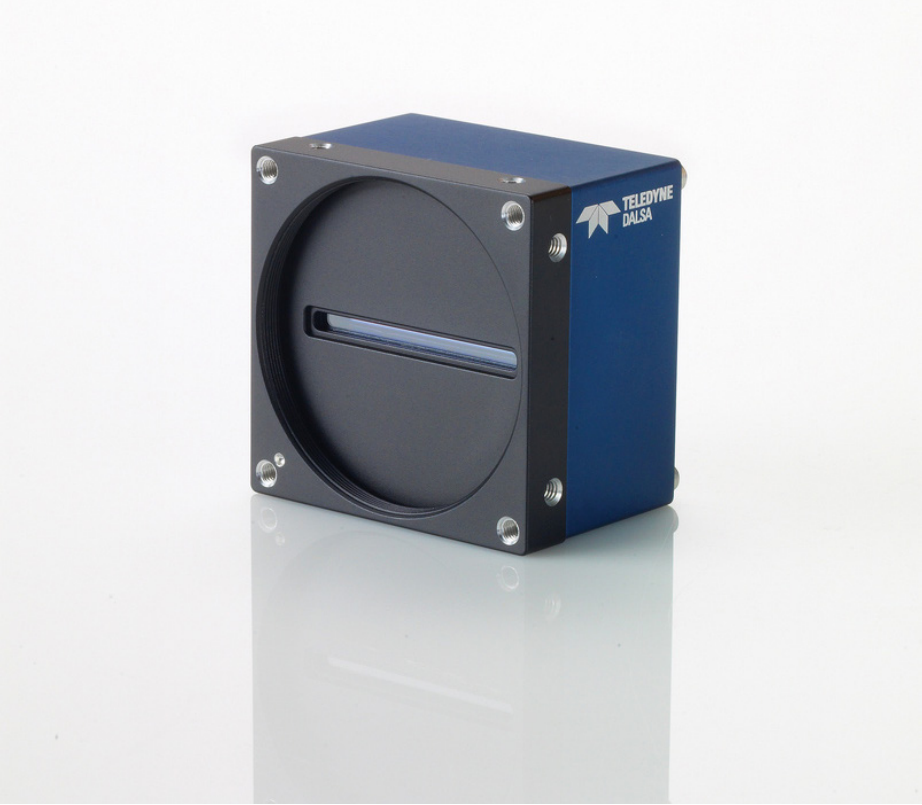
Piranha4

Camera User's Manual

Monochrome 2k and 4k

sensors | **cameras** | frame grabbers | processors | software | vision solutions



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1. System Precautions and Cleaning

Precautions

Read these precautions and this manual carefully before using the camera.

Confirm that the camera's packaging is undamaged before opening it. If the packaging is damaged please contact the related logistics personnel.

Do not open the housing of the camera. The warranty is voided if the housing is opened.

Keep the camera's front plate temperature in a range of 0 °C to 65 °C during operation.

Do not operate the camera in the vicinity of strong electromagnetic fields. In addition, avoid electrostatic charging, violent vibration, and excess moisture.

To clean the device, avoid electrostatic charging by using a dry, clean absorbent cotton cloth dampened with a small quantity of pure alcohol. Do not use methylated alcohol. To clean the surface of the camera housing, use a soft, dry cloth. To remove severe stains use a soft cloth dampened with a small quantity of neutral detergent and then wipe dry. Do not use volatile solvents such as benzene and thinners, as they can damage the surface finish. Further cleaning instructions are below.

Though this camera supports hot plugging, it is recommended that you power down and disconnect power to the camera before you add or replace system components.

Electrostatic Discharge and the CMOS Sensor

Image sensors and the camera bodies housing are susceptible to damage from electrostatic discharge (ESD). Electrostatic charge introduced to the sensor window surface can induce charge buildup on the underside of the window. The charge normally dissipates within 24 hours and the sensor returns to normal operation.

2. The Piranha4 Camera

Camera Highlights

Teledyne DALSA expands its Piranha4 dual line CMOS camera family with 4K and 2K resolution models. The new Piranha4 models offer higher speeds and more responsive pixels in a choice of sizes and resolutions. Programmable features include multiple region-of-interest, high dynamic range operation, and rapid bi-directional switching, and are designed to meet today's demanding imaging applications.

Key Features

- High speed: up to 100 kHz in TDI mode and up to 200 kHz in Area mode
- Combination of various pixel sizes and resolutions
- Bi-directional
- Compact camera body

Programmability

- Multiple Regions of Interest for calibration and data reduction
- 8, 10, and 12 bit output
- Flat field and lens shading correction
- 8 programmable coefficient sets
- GenICam or ASCII compliant interfacing

Applications

- Automated optical inspection
- Transportation safety and security systems
- High performance sorting systems
- Materials grading and inspection systems
- Web inspection
- General purpose machine vision

Models

The camera is available in the following configurations:

Table 1: Camera Models Comparison

Piranha4 Dual Line Model Comparison			
Part Number	**Resolution**	**Maximum Line Rates TDI Mode (Area Mode)**	**Pixel Size**
P4-CM-04K10D-00-R	4096 x 2 pixels	100 kHz (200 kHz)	10.56 µm x 10.56 µm
P4-CM-04K05D-00-R	4096 x 2 pixels	50 kHz (200 kHz)	10.56 µm x 10.56 µm
P4-CM-02K10D-00-R	2048 x 2 pixels	100 kHz (200 kHz)	10.56 µm x 10.56 µm
P4-CM-02K05D-00-R	2048 x 2 pixels	50 kHz (200 kHz)	10.56 µm x 10.56 µm

Table 2: Software

Software	Product Number / Version Number
Camera firmware	Embedded within camera
GenICam™ support (XML camera description file)	Embedded within camera
Sapera LT, including CamExpert GUI application and GenICam for Camera Link imaging driver	Version 7.20 or later

Camera Performance Specifications

Table 3: Camera Performance Specifications

Specifications	Performance
Imager Format	High speed CMOS dual line scan
Resolution	4096 x 2 and 2048 x 2 pixels
Pixel Size	10.56 µm x 10.56 µm
Pixel Fill Factor	100 %
Line Rate	Up to 100 kHz in TDI mode (200 kHz area mode)
Exposure Time	4 µs to 3 ms
Bit Depth	8, 10, and 12 bit, selectable
Connectors and Mechanicals	
Control & Data Interface	Base, Medium, Full, and Deca Camera Link configurations (2 x SDR-26)
Power Connector	Hirose 6-pin male circular
Power Supply	+ 12 V to + 24 V DC (+11.4 V to +25.2 V maximum limits)
Power Dissipation	< 11 W (4K), < 8.3 W (2K)
Size	62 mm (W) x 62 mm (H) x 48 mm (D)
Mass	< 340 g
Operating Temp	0 °C to 65 °C, front plate temperature
Optical Interface	
Lens Mount	M58 x 0.75 (4k) and M42 x 1(2k), F-mount adapter available
Sensor to Camera Front Distance	12 mm
Sensor Alignment (aligned to sides of camera)	

Θ y (parallelism)	0.08° or 100 µm
x	± 100 µm
y	± 100 µm
z	± 250 µm
Θ z	± 0.2°
Compliance	
Regulatory Compliance	CE, FCC, and RoHS; GenICam

Operating Ranges	Performance		Notes
	Single Line	Dual Line	
Dynamic Range	61.5 dB	60 dB	
Random Noise	3.42 DN* rms	4.16 DN rms	FFC enabled
Broadband Responsivity	430 DN/(nJ/cm²)	677 DN/(nJ/cm²)	
Gain	1x to 10x Nominal range	1x to 10x Nominal range	
DC Offset	7 DN	14 DN	FFC enabled
PRNU	< 1% @ 50% Sat	< 1% @ 50% Sat	
FPN	< 8 DN	< 8 DN	
SEE	9.52 nJ / cm²	6.05 nJ / cm²	
NEE	7.95 pJ / cm²	6.14 pJ /cm²	
Antiblooming	> 100 x Saturation	> 100 x Saturation	
Integral non-linearity	1.5 % DN	2.5 % DN	

*DN = digital number

Test Conditions:

- Values measured using 12-bit, 1x gain.
- 10 kHz line rate
- Light source: broadband, quartz halogen, 3250 K with 700 nm IR cut-off filter.
- Front plate temperature: 45° C

Certifications and Compliance

Compliance
EN 55011, FCC Part 15, CISPR 11, and ICES-003 Class A Radiated Emissions Requirements
EN 55024 and EN 61326-1 Immunity to Disturbance
RoHS per EU Directive 2011/65/EC and WEEE per EU Directive 2002/96/EC and China Electronic Industry Standard SJ/T11364-2006
GenICam XML Description File, Superset of the GenICam™ Standard Features Naming Convention specification V1.5, Camera Link Serial Communication: GenICam™ Generic Control Protocol (GenCP V1.0)

Supported Industry Standards

GenICam™

Piranha4 cameras are GenICam compliant. They implement a superset of the GenICam™ Standard Features Naming Convention specification V1.5.

This description takes the form of an XML device description file respecting the syntax defined by the GenApi module of the GenICam™ specification. The camera uses the GenICam™ Generic Control Protocol (GenCP V1.0) to communicate over the Camera Link serial port.

For more information see www.genicam.org.

Responsivity

The responsivity graph describes the sensor response to different wavelengths of light (excluding lens and light source characteristics).

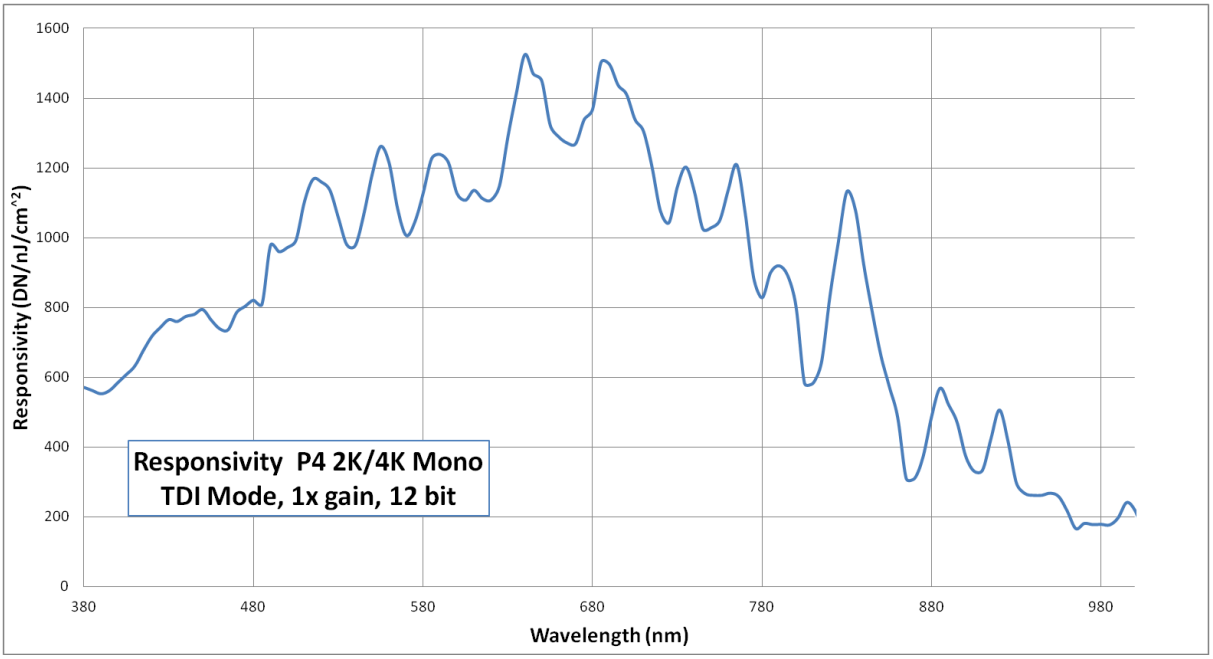


Figure 1: Spectral Responsivity vs. Wavelength (Dual Line)

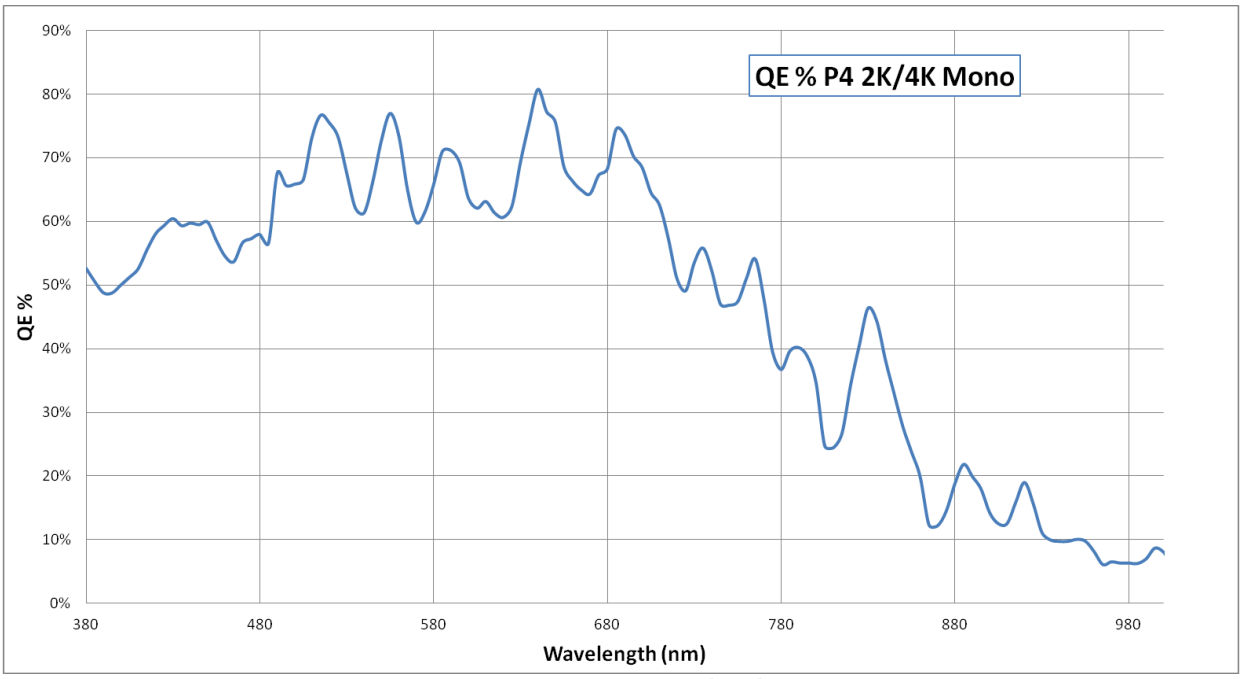


Figure 2: QE % vs. Wavelength

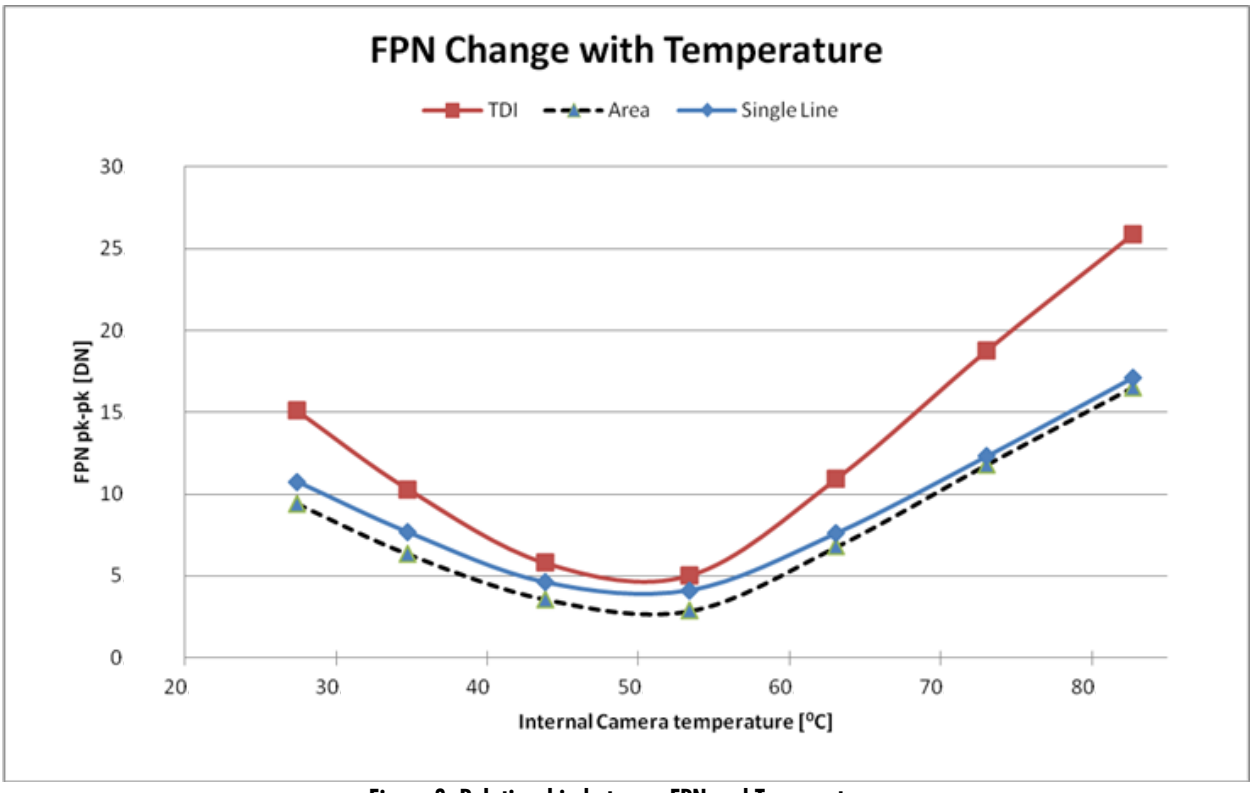


Figure 3: Relationship between FPN and Temperature

Mechanicals

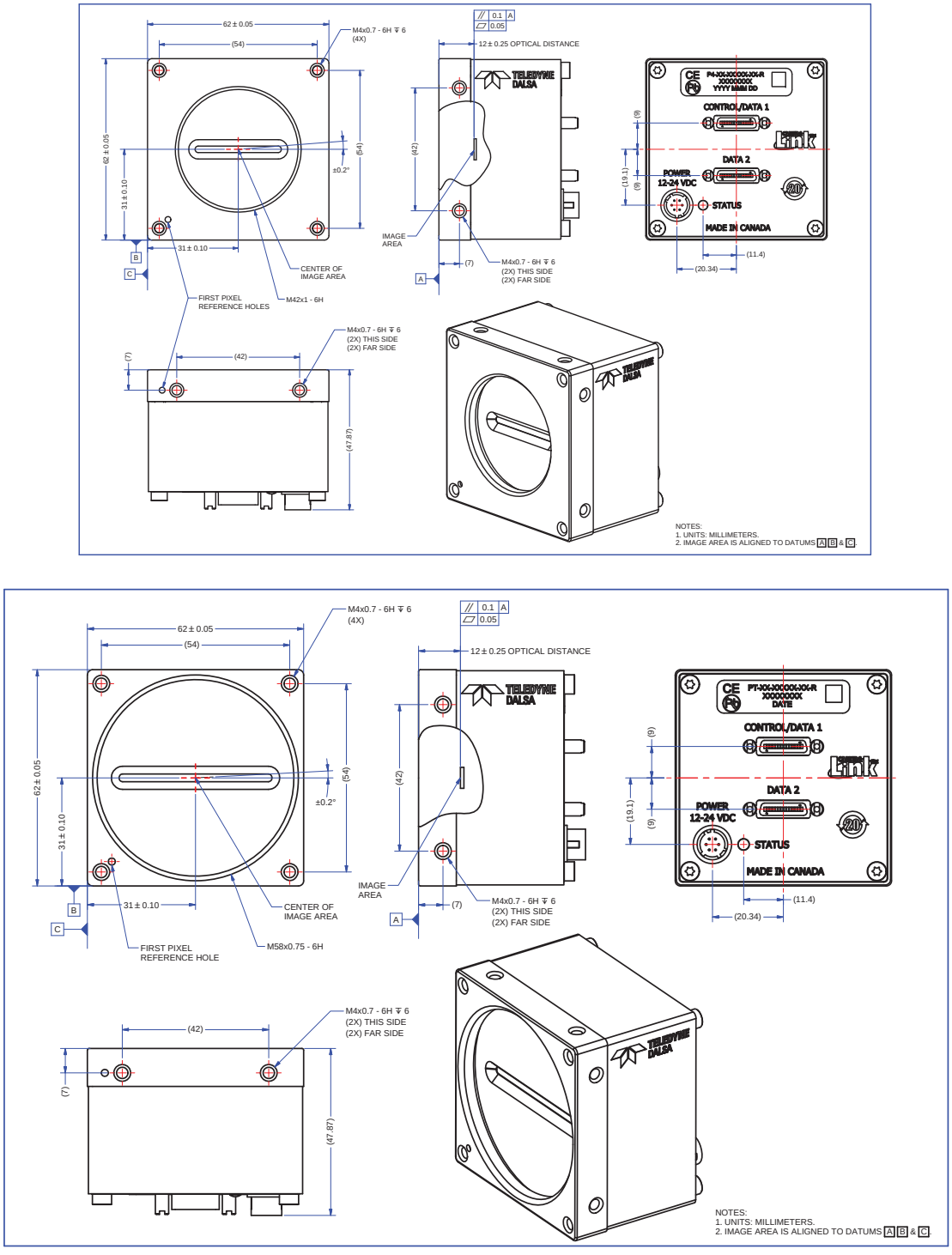


Figure 4: 2K (Top) and 4K (Bottom) Camera Mechanicals

Figure 5: Nikon M58 to F-Mount Adapter

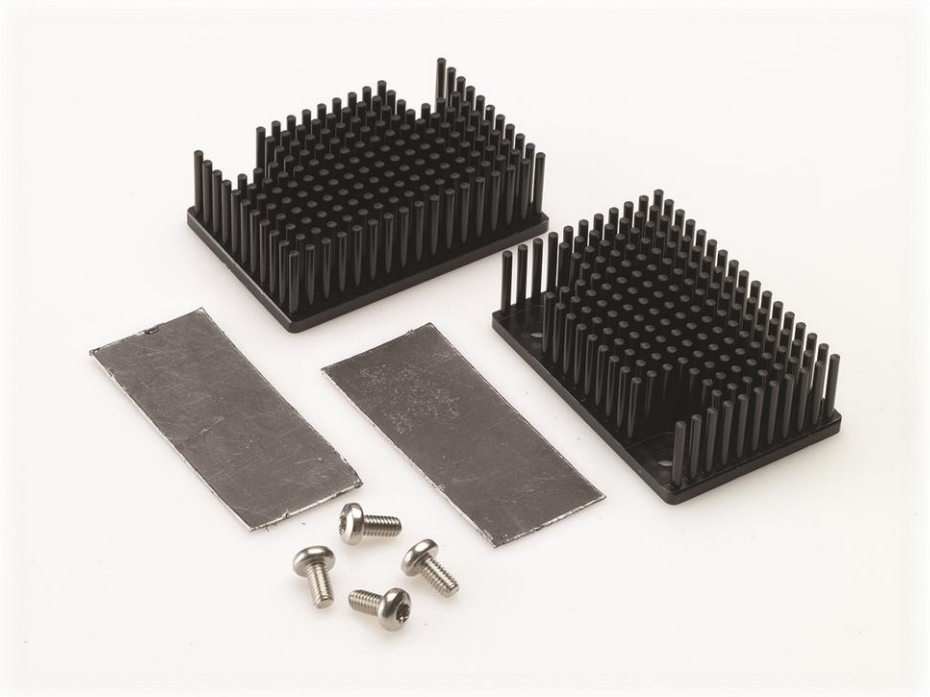


Figure 6: Piranha4 Heat Sink Accessories Kit

Optional Lens Mount and Heat Sink Accessories

Part No.	Description
AC-LN-00002-A0-R	M58 to F-mount adapter (12mm BFD), heavy duty—4k model.
AC-LC-00001-00-R	M42 x 1 F-mount adapter—2k model.
AC-MS-00108-00-R	Heat sink for P4-4k/2k cameras.

Camera Mounting and Heat Sink Considerations

Up to two optional heat sinks can be installed on the Piranha4 camera. As illustrated, they are ideally positioned to allow close spacing of the cameras. These heat sinks are designed to provide adequate convection cooling when not obstructed by enclosures or mounting assemblies.

Teledyne DALSA recognises that each customer's application can be unique. In consideration, the P4 camera heat sinks have been designed in such a way that they can be repositioned on the different faces of the camera or removed entirely, depending on the mounting configuration and its heat sinking potential.

Repositioning or removal of the heat sinks must be performed with care in order to avoid temperature issues. The camera has the ability to measure its internal temperature. Use this feature to record the internal temperature of the camera when it is mounted in your system and operating under the worst case conditions. The camera will stop outputting data if its internal temperature reaches 80 °C. Refer to the Verify Temperature and Voltage section for more information.

3. Quick, Simple Steps to Acquire an Image

For users who are familiar with Camera Link cameras, have a basic understanding of their imaging requirements, and who are primarily interested in evaluating the Piranha4 camera, an overview of the steps required to get this camera operational and acquiring images quickly can be found in Appendix D: Quick Setup and Image Acquisition.

4. Software and Hardware Setup

Recommended System Requirements

To achieve best system performance, the following minimum requirements are recommended:

- High bandwidth frame grabber, e.g. Xcelera-CL PX8 Full Camera Link frame grabber (Part # OR-X8CO-XPF00): www.teledynedalsa.com/imaging/products/fg/OR-X8C0-XPF00/.
- Operating systems: Windows XP / Vista / 7, 32 / 64-bit.

Setup Steps: Overview

Take the following steps in order to setup and run your camera system. They are described briefly below and in more detail in the sections that follow.

1. Install and Configure Frame Grabber and Software

We recommend the Xcelera-CL PX8 Full frame grabber or equivalent, described in detail on the teledynedalsa.com site here. Follow the manufacturer's installation instructions.

A GenICam™ compliant XML device description file is embedded within the camera firmware allowing GenICam™ compliant application to know the camera's capabilities immediately after connection. Installing SaperaLT gives you access to the CamExpert GUI, a GenICam™ compliant application.

2. Connect Camera Link and Power Cables

- Connect the Camera Link cables from the camera to the computer.
- Connect a power cable from the camera to a power supply that can provide a constant voltage between +12 VDC and +24 VDC.

3. Establish Communicating with the Camera

Start the GUI and establish communication with the camera.

ASCII Commands

As an alternative to the CamExpert (or equivalent) GUI, you can communicate with this camera using ASCII-based commands. Open up an ASCII interface and press the ESC key, then the communication mode will be switched into the ASCII command mode other than the GenICam mode. A complete list of the commands and a description of how to access them can be found in Appendix B: ASCII Commands.

4. Operate the Camera

At this point you will be ready to start operating the camera in order to acquire images, set camera functions, and save settings.

Step 1. Install and Configure the Frame Grabber and Software

Install Frame Grabber

Install a Full configuration Camera Link frame grabber according to the manufacturer's description.

We recommend the Xcelera-CL PX8 frame grabber or equivalent, described in detail on the teledynedalsa.com site here.

Install Sapera LT and CamExpert GUI

Communicate with the camera using a Camera Link-compliant interface. We recommend you use CamExpert. CamExpert is the camera interfacing tool supported by the Sapera library and comes bundled with SaperaLT. Using CamExpert is the simplest and quickest way to send commands to and receive information from the camera.

Camera Link Control Communications
The P4 family of cameras are GenICam™ compliant. Sapera uses the GenICam™ Generic Control Protocol (GenCP V1.0) to communicate with the camera over the Camera Link serial port. When communications are first established Sapera will when connecting for the first time download the GenICam™ XML Description file. This file details how to access and control the camera.

Step 2. Connect Data, Trigger, and Power Cables

Note: the use of cables types and lengths other than those specified may result in increased emission or decreased immunity and performance of the camera.

Figure 7: Input and Output, Trigger, and Power Connectors

WARNING! Grounding Instructions
Static electricity can damage electronic components. It's critical that you discharge any static electrical charge by touching a grounded surface, such as the metal computer chassis, before handling the camera hardware.

Data Connector: Camera Link

The camera uses two Camera Link SDR26 cables transmitting the Camera Link Base, Medium, or Full configuration. The figure below shows the SDR26 Camera Link Connector and the tables that follow list the Camera Link Base, Medium, and Full configurations.

For detailed information on Camera Link please refer to the Camera Link Road Map available from the Knowledge Center on the Teledyne DALSA Web site: (http://www.teledynedalsa.com/mv/knowledge/appnotes.aspx).

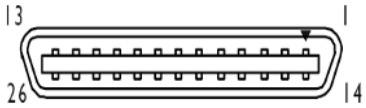


Figure 8. Camera Link Connector

Data 2			Control / Data 1		
Camera Connector	Right Angle Frame Grabber Connector	Channel Link Signal	Camera Connector	Right Angle Frame Grabber Connector	Channel Link Signal
1	1	inner shield	1	1	inner shield
14	14	inner shield	14	14	inner shield
2	25	Y0-	2	25	X0-
15	12	Y0+	15	12	X0+
3	24	Y1-	3	24	X1-
16	11	Y1+	16	11	X1+
4	23	Y2-	4	23	X2-
17	10	Y2+	17	10	X2+
5	22	Yclk-	5	22	Xclk-
18	9	Yclk+	18	9	Xclk+
6	21	Y3-	6	21	X3-
19	8	Y3+	19	8	X3+
7	20	100 ohm	7	20	SerTC+
20	7	terminated	20	7	SerTC-
8	19	Z0-	8	19	SerTFG-
21	6	Z0+	21	6	SerTFG+
9	18	Z1-	9	18	CC1-
22	5	Z1+	22	5	CC1+
10	17	Z2-	10	17	CC2+
23	4	Z2+	23	4	CC2-
11	16	Zclk-	11	16	CC3-
24	3	Zclk+	24	3	CC3+
12	15	Z3-	12	15	CC4+
25	2	Z3+	25	2	CC4-
13	13	inner shield	13	13	inner shield
26	26	inner shield	26	26	inner shield

*Exterior Overshield is connected to the shells of the connectors on both ends. Unused pairs should be terminated in 100 ohms at both ends of the cable. Inner shield is connected to signal ground inside camera

Full Configuration

8 bits Camera Link Full Configuration

Connector 1: Channel link X		Connector 2: Channel link Y		Connector 3: Channel link Z	
Camera/Frame Grabber Pin	Bit Name	Camera/Frame Grabber Pin	Bit Name	Camera/Frame Grabber Pin	Bit Name
Tx0/Rx0	D0(0)	Tx0/Rx0	D3(0)	Tx0/Rx0	D6(0)
Tx1/Rx1	D0(1)	Tx1/Rx1	D3(1)	Tx1/Rx1	D6(1)
Tx2/Rx2	D0(2)	Tx2/Rx2	D3(2)	Tx2/Rx2	D6(2)
Tx3/Rx3	D0(3)	Tx3/Rx3	D3(3)	Tx3/Rx3	D6(3)
Tx4/Rx4	D0(4)	Tx4/Rx4	D3(4)	Tx4/Rx4	D6(4)
Tx5/Rx5	D0(7)	Tx5/Rx5	D3(7)	Tx5/Rx5	D6(7)
Tx6/Rx6	D0(5)	Tx6/Rx6	D3(5)	Tx6/Rx6	D6(5)
Tx7/Rx7	D1(0)	Tx7/Rx7	D4(0)	Tx7/Rx7	D7(0)
Tx8/Rx8	D1(1)	Tx8/Rx8	D4(1)	Tx8/Rx8	D7(1)
Tx9/Rx9	D1(2)	Tx9/Rx9	D4(2)	Tx9/Rx9	D7(2)
Tx10/Rx10	D1(6)	Tx10/Rx10	D4(6)	Tx10/Rx10	D7(6)
Tx11/Rx11	D1(7)	Tx11/Rx11	D4(7)	Tx11/Rx11	D7(7)
Tx12/Rx12	D1(3)	Tx12/Rx12	D4(3)	Tx12/Rx12	D7(3)
Tx13/Rx13	D1(4)	Tx13/Rx13	D4(4)	Tx13/Rx13	D7(4)
Tx14/Rx14	D1(5)	Tx14/Rx14	D4(5)	Tx14/Rx14	D7(5)
Tx15/Rx15	D2(0)	Tx15/Rx15	D5(0)	Tx15/Rx15	Not Used
Tx16/Rx16	D2(6)	Tx16/Rx16	D5(6)	Tx16/Rx16	Not Used
Tx17/Rx17	D2(7)	Tx17/Rx17	D5(7)	Tx17/Rx17	Not Used
Tx18/Rx18	D2(1)	Tx18/Rx18	D5(1)	Tx18/Rx18	Not Used
Tx19/Rx19	D2(2)	Tx19/Rx19	D5(2)	Tx19/Rx19	Not Used
Tx20/Rx20	D2(3)	Tx20/Rx20	D5(3)	Tx20/Rx20	Not Used
Tx21/Rx21	D2(4)	Tx21/Rx21	D5(4)	Tx21/Rx21	Not Used
Tx22/Rx22	D2(5)	Tx22/Rx22	D5(5)	Tx22/Rx22	Not Used
Tx23/Rx23	Not Used	Tx23/Rx23	Not Used	Tx23/Rx23	Not Used
Tx24/Rx24	LVAL	Tx24/Rx24	LVAL	Tx24/Rx24	LVAL
Tx25/Rx25	FVAL	Tx25/Rx25	FVAL	Tx25/Rx25	FVAL
Tx26/Rx26	Not Used	Tx26/Rx26	Not Used	Tx26/Rx26	Not Used
Tx27/Rx27	D0(6)	Tx27/Rx27	D3(6)	Tx27/Rx27	D6(6)

Tap 1 bits are D0(x)...Tap 8 bits are D7(x)

Camera Link Bit Definitions

BASE Configuration	T0		
Pixel Format	**Port A Bits 0 thru 7**	**Port B Bits 0 thru 7**	**Port C Bits 0 thru 7**
Mono 8	Tap 1 LSB..Bit 7 Pixels (1, 3, 5, ... 4093, 4095)	Tap 2 LSB..Bit7 Pixels (2, 4, 6, ... 4094, 4096)	xxxxxxx
Mono 12	Tap 1 LSB.. Bit 7 Pixels (1, 3, 5, ... 84093, 4095)	Tap 1 Bits 8,9,10,11 Pixels (1, 3, 5, ... 4093,4095) Tap 2 Bits 8,9,10,11 Pixels (2,4,6, ... 4094, 4096)	Tap 2 LSB..Bit 7 Pixels (2,4,6, ... 4094, 4096)

Medium Configuration	T0					
Pixel Format	**Port A Bits 0 thru 7**	**Port B Bits 0 thru 7**	**Port C Bits 0 thru 7**	**Port D Bits 0 thru 7**	**Port E Bits 0 thru 7**	**Port F Bits 0 thru 7**
Mono 8	Tap 1 LSB..Bit 7 Pixels (1, 5, 9, ... 4089, 4093)	Tap 2 LSB..Bit 7 Pixels (2, 6, 10, ... 4090, 4094)	Tap 3 LSB..Bit 7 Pixels (3, 7, 11, ... 4091, 4095)	Tap 4 LSB...Bit 7 Pixels (4, 8, 12, ... 4092, 4096)	xxxxxxxx	Xxxxxxxx
Mono 10 / Mono 12	Tap 1 LSB.. Bit 7 Pixels (1, 5, 9, ... 4091, 4095)	Tap 1 Bits 8,9,10,11 Pixels (1, 5, 9, ... 4091, 4095) Tap 2 Bits 8,9,10,11 Pixels (2, 6, 10, ... 4092, 4096)	Tap 2 LSB..Bit 7 Pixels (2, 6, 10, ... 4092, 4096)	Tap 4 LSB…Bit 7 Pixels (4, 8, 12, ... 4090, 4094)	Tap 3 LSB…Bit 7 Pixels (3, 7, 11, ... 4089, 4093)	Tap 3 Bit 8,9,10,11 Pixels (3, 7, 11, ... 4089, 4093) Tap 4 Bits 8,9,10,11 Pixels (4, 8, 12, ... 4090, 4094)

Full Configuration	T0							
Pixel Format	**Port A LSB…Bit 7**	**Port B LSB…Bit 8**	**Port C LSB…Bit 8**	**Port D LSB…Bit 8**	**Port E LSB…Bit 8**	**Port F LSB…Bit 8**	**Port G LSB…Bit 8**	**Port H LSB…Bit 8**
Mono 8	Tap 1 LSB… Bit 7 Pixels (1, 9, 17, ... 4081, 4089)	Tap 2 LSB… Bit 7 Pixels (2, 10, 18, ... 4082, 4090)	Tap 3 LSB… Bit 7 Pixels (3, 11, 19, ... 4083, 4091)	Tap 4 LSB… Bit 7 Pixels (4, 12, 20, ... 4084, 4092)	Tap 5 LSB… Bit 7 Pixels (5, 13, 21, ... 4085, 4093)	Tap 6 LSB… Bit 7 Pixels (6, 14, 22, ... 4086, 4094)	Tap 7 LSB…Bit 7 Pixels (7, 15, 23, ... 4087, 4095)	Tap 8 LSB… Bit 7 Pixels (8, 16, 24, ... 4088, 4096)

Deca Configuration	T0									
Pixel Format	Port A LSB… Bit 7	Port B LSB… Bit 8	Port C LSB… Bit 8	Port D LSB… Bit 8	Port E LSB… Bit 8	Port F LSB… Bit 8	Port G LSB… Bit 8	Port H LSB… Bit 8	Port I LSB…Bit 8	Port K LSB…Bit 8
Mono 8	Tap 1 LSB… Bit 7 Pixels (1, 11, 21, ... 4081, 4091)	Tap 2 LSB… Bit 7 Pixels (2, 12, 22, ... 4082, 4092)	Tap 3 LSB… Bit 7 Pixels (3, 13, 23, ... 4083, 4093)	Tap 4 LSB… Bit 7 Pixels (4, 14, 24, ... 4084, 4094)	Tap 5 LSB… Bit 7 Pixels (5, 15, 25, ... 4085, 4095)	Tap 6 LSB… Bit 7 Pixels (6, 16, 26, ... 4086, 4096)	Tap 7 LSB… Bit 7 Pixels (7, 17, 27, ... 4087)	Tap 8 LSB… Bit 7 Pixels (8, 18, 28, ... 4088)	Tap 9 LSB… Bit 7 Pixels (9, 19, 29, ... 4089)	Tap 10 LSB… Bit 7 Pixels (10, 20, 30, ... 4090)

Table 4: Camera Link Bit Definitions

Signal	Configuration
CC1	EXSYNC
CC2	Spare
CC3	Direction
CC4	Spare

Table 5: Camera Control Configuration

For additional Camera Link documentation refer to the Teledyne DALSA Web site's Knowledge Center application notes.

Camera Link Drive Capability

The camera link cable drive capability on P4-4K/2K cameras has been improved to reach up to 15 meters. This provides longer cable lengths without the need for additional components like, repeaters etc. This capability has been tested using a number of frame grabbers (listed in the table below) and was tested using standard Camera Link cables. The cable length drive achieved on the various frame grabbers is as follows:

Cable Length	Frame Grabber (Manufacturer/Part Number)
10 m	TeledyneDALSA Xcelera-CL PX4 / OR-X4C0-XPF00 TeledyneDALSA Xcelera-CL+ PX8 Full / OR-X8C0-XPF00 Matrox Radient eCL – RAD2GSF150400
15 m	TeledyneDALSA Xcelera-CL+ PX8 Full / OR-X8C0-XPF00

Table 6: Cable Length and Frame Grabber Pairings

Input Signals, Camera Link

The camera accepts control inputs through the Camera Link SDR26F connector. The camera ships in internal sync, and internally programmed integration.

EXSYNC (Line Readout Trigger)

Line rate can be set internally using the GenICam features. The external control signal EXSYNC is optional and enabled through the user interface. This camera uses the falling edge of EXSYNC to trigger pixel readout.

The EXSYNC signal tells the camera when to integrate and readout the image. It can be either an internally generated signal by the camera, or it can be supplied externally via the serial interface. Depending upon the mode of operation the high time of the EXSYNC signal can represent the integration period.

Note: The EXSYNC signal is measured at CC1 and will give a "true" measurement (i.e. within the measurement resolution of 25 ns) even though the camera will only trigger at a maximum of 100 kHz.

Output Signals, Camera Link Clocking Signals

These signals indicate when data is valid, allowing you to clock the data from the camera to your acquisition system. These signals are part of the Camera Link configuration and you should refer to the Camera Link Implementation Road Map, available at our Knowledge Center, for the standard location of these signals.

Clocking Signal	Indicates
LVAL (high)	Outputting valid line
DVAL	Not used
STROBE (rising edge)	Valid data
FVAL	Set to 0

Power Connector

WARNING: It is extremely important that you apply the appropriate voltages to your camera. Incorrect voltages may damage the camera. Input voltage requirement: +12 VDC to +24 VDC, 2 Amps. Before connecting power to the camera, test all power supplies.

Figure 9: 6-pin Hirose Circular Male Power Plug—Power Connector

Table 7. Power Plug Pinout

Pin	Description	Pin	Description
1	+12 V to +24 V DC	4	GND
2	+12 V to +24 V DC	5	GND
3	+12 V to +24 V DC	6	GND

The camera requires a single voltage input +12 VDC to +24 VDC. The camera meets all performance specifications using standard switching power supplies, although well-regulated linear supplies provide optimum performance.

WARNING: When setting up the camera's power supplies follow these guidelines:

- Apply the appropriate voltages.
- Protect the camera with a 2 amp slow-blow fuse between the power supply and the camera.
- Do not use the shield on a multi-conductor cable for ground.
- Keep leads as short as possible in order to reduce voltage drop.
- Use high-quality supplies in order to minimize noise.

Note: If your power supply does not meet these requirements, then the camera performance specifications are not guaranteed.

LEDs

The camera is equipped with an LED on the back to display the operational status of the camera. The table below summarizes the operating states of the camera and the corresponding LED states. When more than one condition is active, the LED indicates the condition with the highest priority.

Color of Status LED	Meaning
Off	No power or hardware malfunction
Blinking	Powering up or calibrating
Green	Ready
Red	Error. Check the built-in self test (BiST) register for the specific error

Step 3. Establish Communication with the Camera

Power on the camera

Turn on the camera's power supply. You may have to wait while the camera readies itself for operation. The camera must boot fully before it will be recognized by the GUI—the LED shines green once the camera is ready.

Connect to the frame grabber

1. Start Sapera CamExpert (or equivalent Camera Link compliant interface) by double clicking the desktop icon created during the software installation.
2. CamExpert will search for installed Sapera devices. In the Devices list area on the left side, the connected frame grabber will be shown.
3. Select the frame grabber device by clicking on the name.

Note: The first time you set up the camera you will need to establish a communication link between the camera and frame grabber.

Connect to the camera

1. Start a new Sapera CamExpert application (or equivalent Camera Link compliant interface) by double clicking the desktop icon created during the software installation.
2. In the Devices list area on the left side, select the COM port below the Camera Link label.

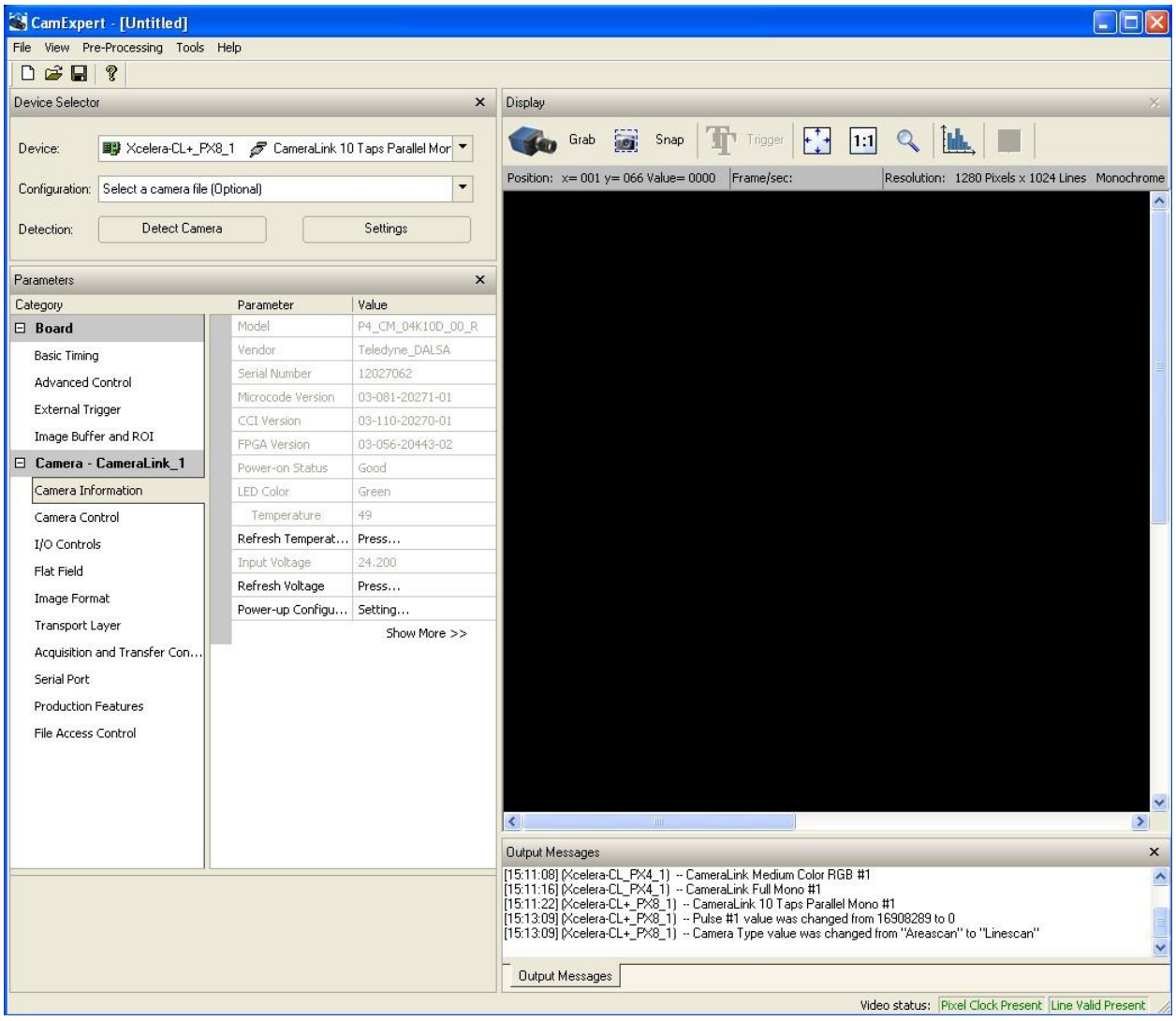


Figure 10. CamExpert GUI showing connected camera

Check LED Status

If the camera is operating correctly at this point, the diagnostic LED will shine green.

Software Interface

All the camera features can be controlled through the CamExpert interface. For example, under the Camera Control menu in the camera window you can control the line rate and exposure times.

At this point your host and camera system should be setup and you can verify the camera's operation by retrieving a test pattern and setting the camera's trigger and exposure time.

Using Sapera CamExpert with Piranha4 Cameras

CamExpert is the camera interfacing tool supported by the Sapera library. When used with a Piranha4 camera, CamExpert allows a user to test all camera operating modes. Additionally CamExpert saves the camera user settings configuration to the camera or saves multiple configurations as individual camera parameter files on the host system (**.ccf*). CamExpert can also be used to upgrade the camera's software.

An important component of CamExpert is its live acquisition display window which allows immediate verification of timing or control parameters without the need to run a separate acquisition program.

For context sensitive help, click on the button then click on a camera configuration parameter. A short description of the configuration parameter will be shown in a popup. Click on the button to open the help file for more descriptive information on CamExpert.

The central section of CamExpert provides access to the camera features and parameters. **Note**: The availability of the features is dependent on the CamExpert user setting.

A note on the CamExpert examples shown here: The examples shown for illustrative purposes and may not entirely reflect the features and parameters available from the camera model used in your application.

CamExpert Panes

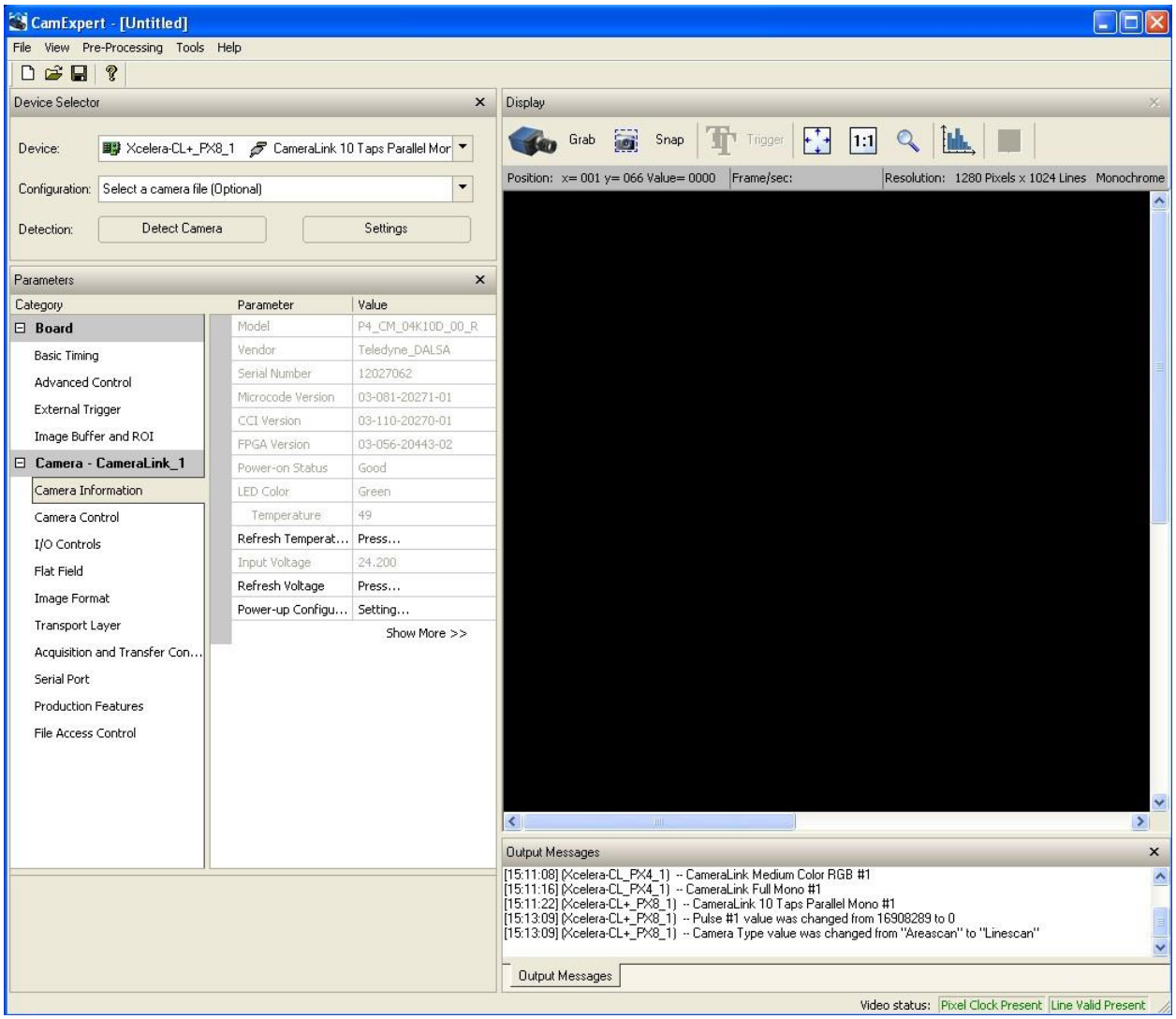
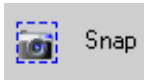


Figure 11. CamExpert's Camera Control Window

The CamExpert application uses panes to simplify choosing and configuring camera files or acquisition parameters for the installed device.

- **Device Selector pane:** View and select from any installed Sapera acquisition device. Once a device is selected CamExpert will only present acquisition parameters applicable to that device. Optionally select a camera file included with the Sapera installation or saved by the user.
- **Parameters pane:** Allows viewing or changing all acquisition parameters supported by the acquisition device. CamExpert displays parameters only if those parameters are supported by the installed device. This avoids confusion by eliminating parameter choices when they do not apply to the hardware in use.
- **Display pane:** Provides a live or single frame acquisition display. Frame buffer parameters are shown in an information bar above the image window.
- **Control Buttons:** The Display pane includes CamExpert control buttons. These are:

	Acquisition control button: Click once to start live grab, click again to stop.
	**Single frame grab:** Click to acquire one frame from device.
	Trigger button: With the I/O control parameters set to Trigger Enabled, click to send a single trigger command.
	CamExpert display controls: (these do not modify the frame buffer data) Stretch image to fit, set image display to original size, or zoom the image to virtually any size and ratio.
	Histogram / Profile tool: Select to view a histogram or line/column profile during live acquisition or in a still image.

- **Output Message pane:** Displays messages from CamExpert or the device driver.

At this point you are ready to start operating the camera in order to acquire images, set camera functions, and save settings.

4. Camera Operation

Factory Settings

The camera ships and powers up for the first time with the following factory settings:

- Camera Link Full, 8 bit pixels
- Internal trigger, line rate 10 kHz
- Internal exposure control, exposure time 50 µs
- 2 stage TDI
- 1x horizontal and vertical binning
- Offset 0, Gain 1x

Area Mode

Using area mode in the P4 mono camera allows data rates to be twice as fast compared to TDI Stage = 1 or TDI Stages = 2.

Similar to TDI Stage = 2 mode, both the top and bottom lines of the sensor are exposed at the same time. The difference being that instead of summing the lines, each line is read out separately. The figure below illustrates how this is done. On the first Exsync signal, both lines are exposed and then the sensor is read out. One line is processed and stored in camera memory while the other line is processed and sent out the Camera Link output. The next Exsync signal does not reach the sensor, but instead the stored data is transferred out the Camera Link port.

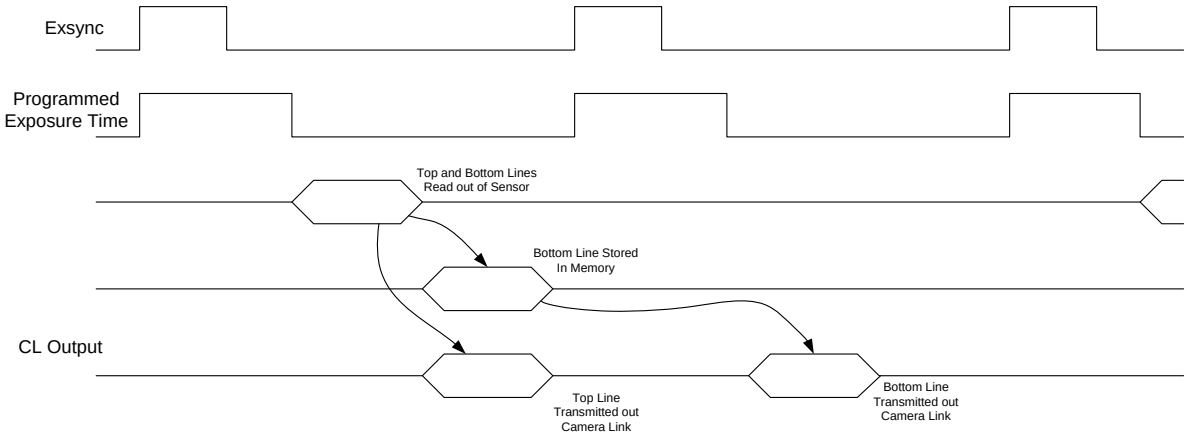


Figure 12. Area Mode data transfer timing

It is important that the exposure time in area mode be appropriate for the set line rate. The exposure time should not be longer than the inverse of the line rate or else the image will smear. The set scan direction is also important. If the direction is wrong the image will look choppy, as can be seen in the following figure.

Figure 13. Image with incorrect scan direction

Figure 14. Image with proper scan direction

Check Camera and Sensor Information

Camera and sensor information can be retrieved via a controlling application—for example, the CamExpert GUI shown in the following examples. Parameters such as camera model, firmware version, sensor characteristics, etc. are read to uniquely identify the connected device.

The camera information parameters are grouped together as members of the Camera Information set.

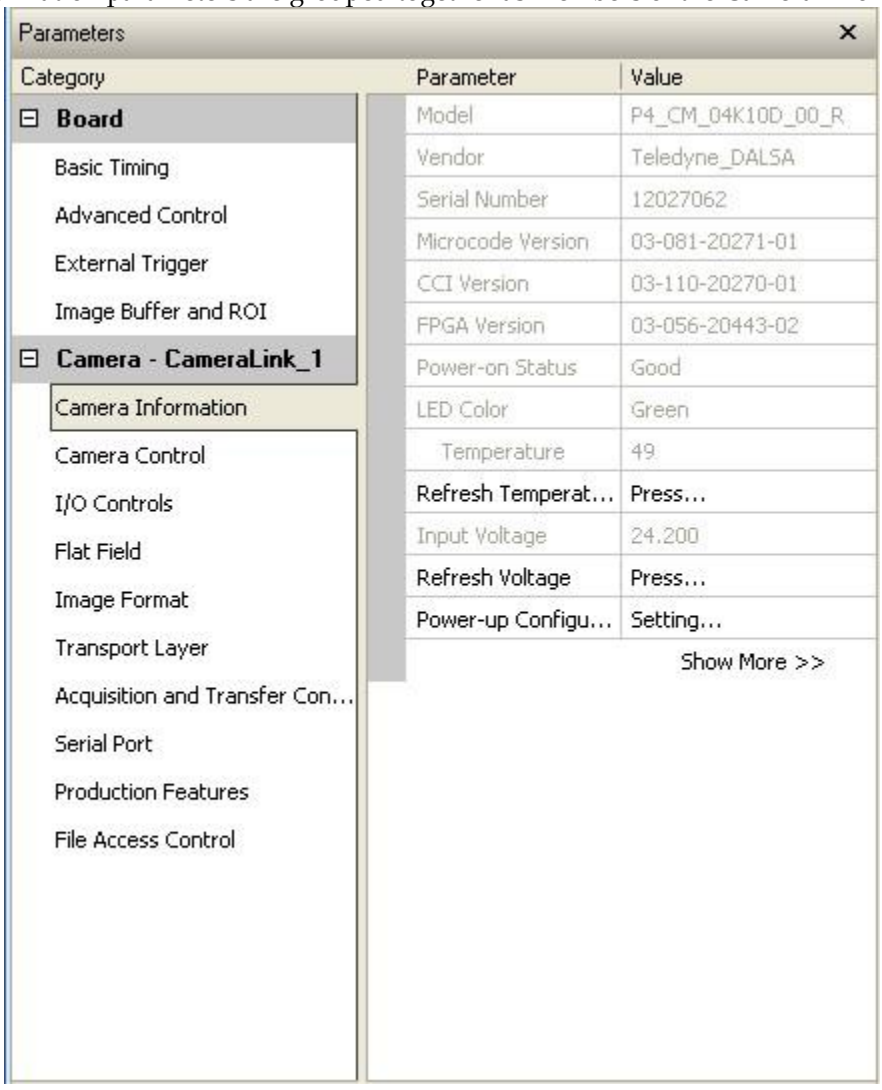


Figure 15. CamExpert's Camera Information Window

Verify Temperature and Voltage

To determine the voltage and temperature at the camera, use the **Refresh Voltage and Refresh Temperature** features found in the **Camera Information** set.

The temperature returned is the internal temperature in degrees Celsius. For proper operation this value should not exceed 80 °C. If the camera exceeds the designated temperature it will stop imaging and the LED will turn red. Once you have diagnosed and remedied the issue use the **reset camera** function.

Note: The voltage displayed is the camera's input voltage. The voltage measurement feature of the camera provides results within 1% of the actual voltage. The measurement can be used to set the applied voltage to the camera.

Saving and Restoring Camera Settings

The parameters used to select, load and save user sets are grouped together under the Camera Information set of features. There are 8 user sets available and one factory set.

Camera Information	
Parameter	**Choices**
User Set Default Selector	Select the camera parameters to load when the camera is reset or powered up as the Factory set, or as User Set 1 to 8. Selecting the set from the list automatically saves it as the default set.
User Set Selector	Select the Factory or User set to Save or Load. -Factory Set -User Set 1 to 8.
User Set Load	Load the set specified by User Set Selector to the camera and make it the active / current set.
User Set Save	Save the current set as selected user set.

Description of the Camera Settings

The camera operates in one of four settings:

1. Current operation with active settings.
2. User setting.
3. Factory setting (read-only).
4. Default setting.

The settings active during the current operation can be saved (thereby becoming the user setting) using the User Set Save parameter. A previously saved user setting (User Set 1 to 8) or the factory settings can be restored using the User Set Selector and User Set Load parameters.

Either the Factory or one of the User settings can be saved as the Default Setting by selecting the set in the User Set Default Selector. The chosen set automatically saves as the default setting and is the set loaded when the camera is reset or powered up.

The relationship between these four settings is illustrated in Figure 16. Relationship between the Camera Settings:

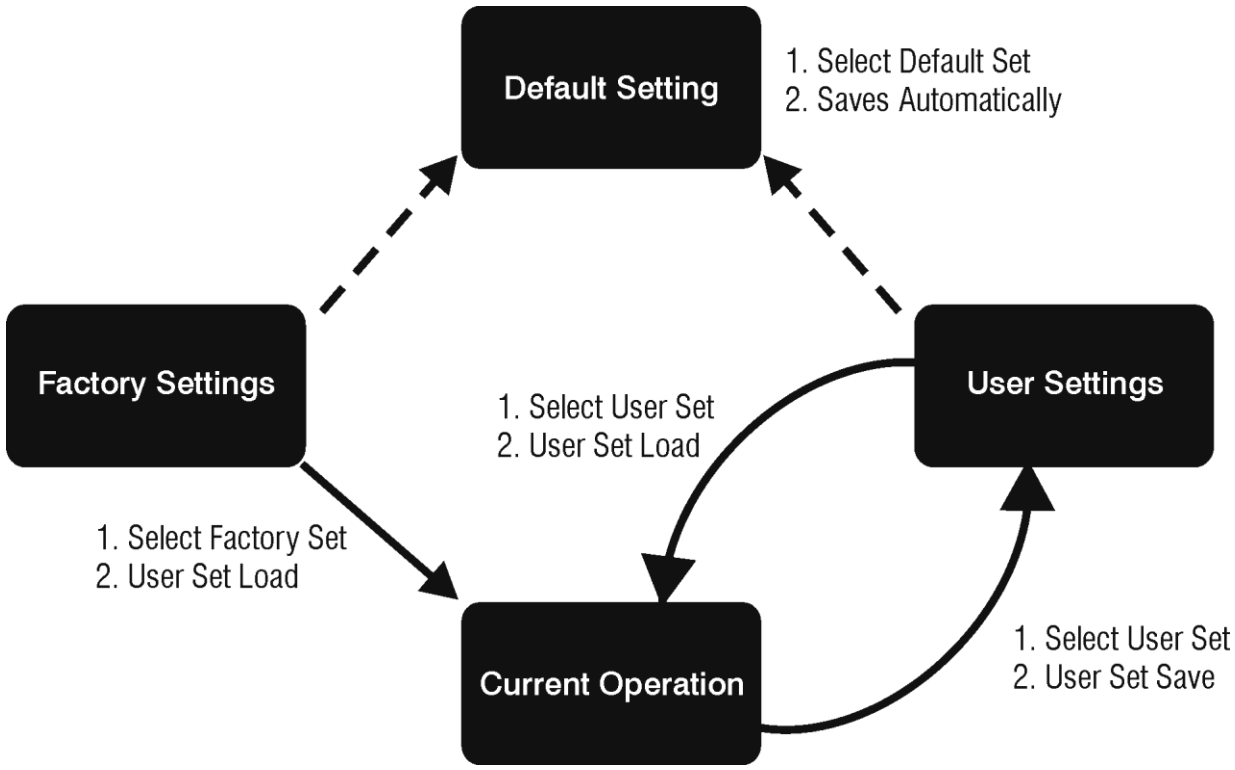


Figure 16. Relationship between the Camera Settings

Active Settings for Current Operation

The active setting for the current operation is the set of configurations that are active while the camera is currently running, including all unsaved changes you have made to the settings before saving them.

These active settings are stored in the camera's *volatile* memory and will be lost and cannot be restored if the camera resets, is powered down, or loses power.

To save these settings for reuse the next time you power up or reset the camera, or to protect against losing them in the case of power loss, you must save the current settings using the **User Set Save** parameter. Once saved, the current settings become the selected **User Set**.

User Setting

The user setting is the saved set of camera configurations that you can customize, resave, and restore. By default the user settings are shipped with the same settings as the factory set.

The command **User Set Save** saves the current settings to non-volatile memory as a **User Set**. The camera automatically restores the last saved user settings when it powers up.

To restore the last saved user settings, select the **User Set** parameter you want to restore and then select the **User Set Load** parameter.

Factory Settings

The factory setting is the camera settings that were shipped with the camera and which loaded during the camera's first power-up. To load or restore the original factory settings, at any time, select the **Factory Setting** parameter and then select the **User Set Load** parameter.

Note: By default, the user settings are set to the factory settings.

Default Setting

Either the Factory or one of the User settings can be used as the Default Setting by selecting the set in the User Set Default Selector. The chosen set automatically becomes the default setting and is the set loaded when the camera is reset of powered up.

Camera Link Configuration

Name	Taps	SPF*	Cables
Base	2	8, 10, 12	1
Medium	4	8, 10, 12	2
Full	8	8	2
Deca (4K only)	10	8	2

*Set Pixel Format (number of bits per pixel)

TDI and Single Line Modes

You have the option to set the camera modes as either single line (where only the bottom sensor is used, which results in lower sensitivity) or as TDI (where the pair of sensor lines is summed, which results in higher sensitivity).

TDI Mode vs. Vertical Binning 2

TDI mode delays one line before summing so that each row images the same area. In the case of vertical binning equal to 2, the rows image adjacent areas and are summed without separation delay. This action, combined with horizontal binning equal to 2, results in a big pixel that has half the resolution but four times the response compared to TDI stages = 1.

TDI Stage 2 vs. Vertical Binning

Vertical Binning and TDI Stage 2 are very similar in operation in that for both modes both lines of the sensor are used and both lines are summed together. The difference is that in vertical binning both lines are summed directly, while in TDI Stages 2 one line is delayed by one EXSYNC before being summed with the other line. The result is a 20 µm tall pixel for vertical binning while TDI Stage 2 maintains the 10 µm pixel height.

There is no line rate difference between these two modes.

Sensitivity Modes and Pixel Readout

The camera has the option to operate in either TDI mode or single line mode. When in TDI mode, the camera uses both line scan sensors and as a result the responsivity increases (57%). When in single line mode, the camera uses the bottom sensor only. The internal gain is 1.27x greater for single line mode vs. TDI mode.

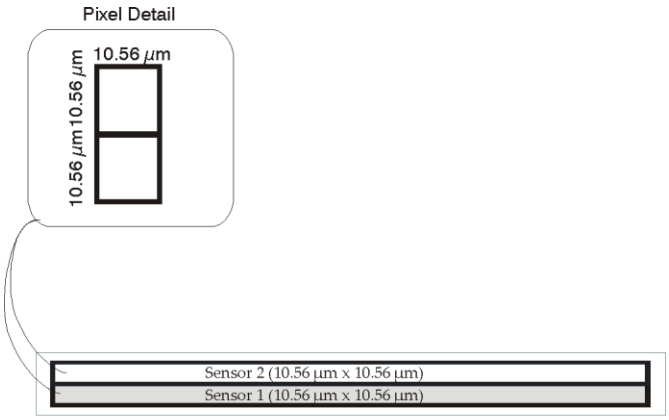


Figure 17: TDI Mode Examples

In TDI mode, the camera uses a 10.56 µm x 10.56 µm pixel and captures the same image twice, resulting in a brighter image.

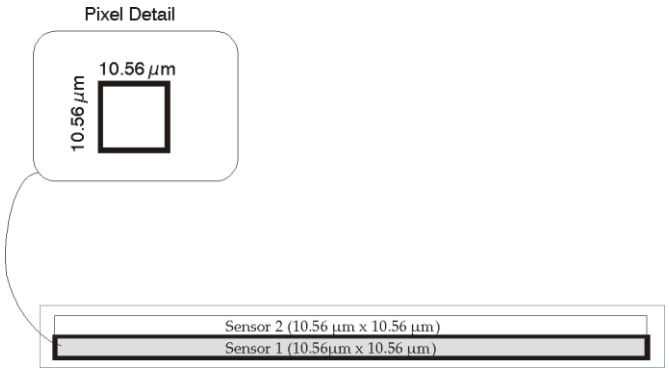


Figure 18: Single Line Mode Examples

In single line mode, the camera uses a 10.56 µm x 10.56 µm pixel and captures the image using one sensor (Sensor 1).

Trigger Modes

The camera's image exposures are initiated by a trigger event. The trigger event is either a programmable internal signal used in free running mode, an external input used for synchronizing exposures to external triggers, or a programmed function call message by the controlling computer. These triggering modes are described below.

- **Internal trigger (trigger disabled):** The camera free-running mode has a programmable internal timer for line rate and a programmable exposure period.
- **External trigger (trigger enabled):** Exposures are controlled by an external trigger signal. The external trigger signal is the Camera Link control line CC1.

Exposure Controls

The Exposure Control modes define how and when the camera will capture an image—the integration period. The integration period is the amount of time the camera's sensor is exposed to incoming light before the captured image is transmitted to the controlling computer.

- Exposure control is defined as the start of exposure and exposure duration.
- The start of exposure can be an internal timer signal (free-running mode) or an external trigger signal.
- The exposure duration can be programmable (such as the case of an internal timer) or controlled by the external trigger pulse width.

The camera can grab images in one of three ways. You determine the three imaging modes using a combination of the Exposure Mode parameters (including I/O parameters), Exposure Time and Line Rate parameters.

Description	Line Rate	Exposure Time	Trigger Source (Sync)
Internal line rate and exposure time	Internal, programmable	Internal programmable	Internal
External line rate and exposure time	Controlled by EXSYNC pulse	External (EXSYNC)	External
EXSYNC pulse controlling the line rate. Programmed exposure time.	Controlled by EXSYNC pulse	Internal programmable	External

Figure 19. Exposure controls

The parameters used to select the imaging modes—trigger sources (sync), exposure time, and line rate—are grouped together as the Camera Controls.

Camera Controls	
Parameter	**Description**
Line Rate (in Hz)	Camera line rate in Hz. Only available when the start line trigger parameter is disabled (Trigger Mode off).
Exposure Mode	Set the operation mode for the camera's exposure. Trigger Width or Timed. Trigger Width is only available when Trigger Mode is enabled.
	Trigger Width Uses the width of the current line trigger signal pulse to control the

	exposure duration.
	Timed The exposure duration time is set using the Exposure Time feature and the exposure starts with the Line Start event.
Exposure Time	Sets the exposure time (in microseconds). Exposure Mode feature must be set to Timed

Exposure Modes in Detail

1. Internally Programmable Line rate and Internally Programmable Exposure Time (Default)

Line rate is the dominant factor when adjusting the line rate or exposure time. When setting the line rate, exposure time will decrease, if necessary, to accommodate the new line rate. When adjusting the exposure time the range is limited by the line rate.

Note: The camera will not set line periods shorter than the readout period.

GenICam parameters to set:
I / O Controls > Trigger Mode > Off

2. External Line Rate and External Exposure Time (Trigger Width)

In this mode, EXSYNC sets both the line period and the exposure time. The rising edge of EXSYNC marks the beginning of the exposure and the falling edge initiates readout. Note:

$$\text{maximum line rate} = \frac{1}{(\text{exposure time} + \text{low time}^*)}$$

*Exposure time must be greater than 4 μs, and low time greater than 1 μs

GenICam parameters to set:

- **I / O Controls > Trigger Mode > On**
- **Camera Control > Exposure Mode > Trigger Width**

Warning! When running external line rate and external exposure time, the line rate must not exceed 1 / (exposure time + 1 µs). Under these conditions the exposure time will become indeterminate and result in image artefacts. This is not the case when running internal exposure control.

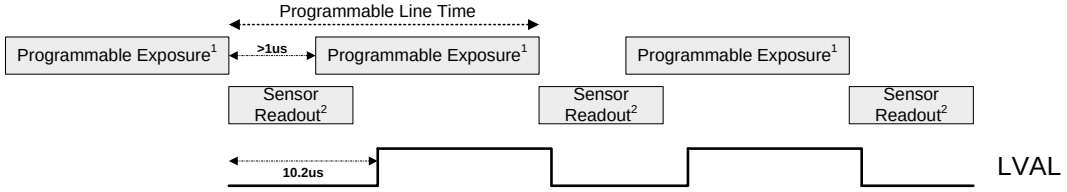
3. External Line Rate, Programmable Exposure Time

In this mode, the line rate is set externally with the falling edge of EXSYNC generating the rising edge of a programmable exposure time.

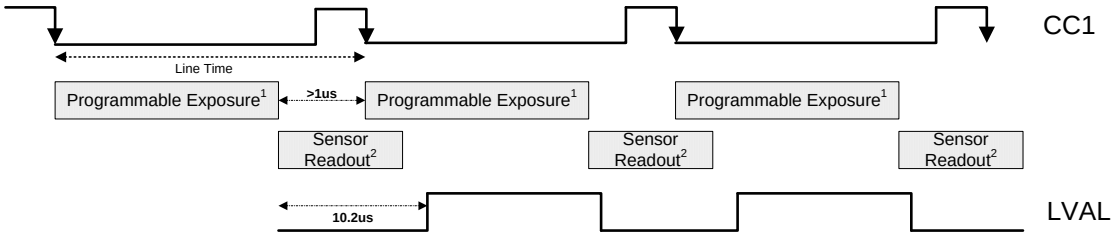
GenICam parameters to set:

- **I / O Controls > Trigger Mode > On**
- **Camera Control > Exposure Mode > Timed**

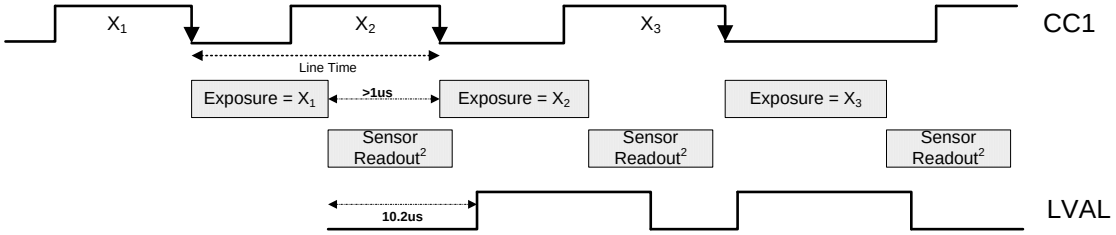
1. External Trigger Off, Internal Exposure Control
   Free running, not synchronized to an external signal



2. External Trigger On, Internal Exposure Control
   CC1 Falling edge triggers start of internal exposure[3]



3. External Trigger On, External Exposure Control
   CC1 Falling edge triggers start of exposure
   CC1 high duration sets the exposure time



Notes:
1. Exposure time > 4 micro-seconds
2. Sensor Readout time = 9.5 micro-seconds
3. One additional falling edge during exposure is latched

Figure 20. Exposure Modes

Set Line Rate

To set the camera's line rate use the line rate parameter, part of the Camera Controls set. This feature can only be used when the camera is in Internal mode—that is, when the start line trigger is disabled (Trigger Mode Off).

$$\text{maximum line rate} = \frac{1}{(\text{exposure time} + \text{low time}^*)}$$

*Exposure time must be greater than 4 μs, and low time greater than 1 μs

Note: A line rate < 1 / (Exposure time + 1 µs) will return an error ("Invalid Parameter") if this condition is not met. You must adjust these two parameters in the correct sequence to maintain this condition.

If the external line rate exceeds the maximum line rate allowed for a mode, the camera will continue to output data at its maximum line rate. Though no image artefacts associated with over-speed will occur, you may notice that under over-speed conditions the image will appear compressed and the apparent distance travelled will be reduced.

Camera Control	
Parameter	**Description**
Line Rate (in Hz)	Camera line rate in a range from 1 Hz up to 100 kHz. This feature is only available when the camera is in Internal Mode—line trigger is disabled (Trigger Mode off).

Line Rates	
Camera Link Configuration	**Maximum Line Rate**
Base, 8-bit	41 kHz (4K), 82 kHz (2K)
Medium, 8-bit	81 kHz(4K), 100 kHz (2K)
Full (TDI) , 8-bit	100 kHz (4K and 2K)
Full (Area) , 8-bit	160 kHz (4K), 200 kHz (2K)
Deca (Area) , 8-bit	200 kHz (4K)

Line Rates Vs. AOI

Table 8: 85 MHz Camera Link Clock Rate. Maximum Line Rates of 100 kHz TDI and 200 kHz Area.

Number of AOI	CL Configuration	Line Rate Formula (Hz)
1	Base	$\frac{85000000}{\left(\frac{AOIwidth1}{2}\right)+15}$
	Medium	$\frac{85000000}{\left(\frac{AOIwidth1}{4}\right)+15}$
	Full	$\frac{85000000}{\left(\frac{AOIwidth1}{8}\right)+15}$
	Deca	$\frac{85000000}{\left(\frac{AOIwidth1}{10}\right)+15}$
2	Base	$\frac{85000000}{\left(\frac{AOIwidth1+AOIwidth2}{2}\right)+15}$
	Medium	$\frac{85000000}{\left(\frac{AOIwidth1+AOIwidth2}{4}\right)+15}$
	Full	$\frac{85000000}{\left(\frac{AOIwidth1+AOIwidth2}{8}\right)+15}$
	Deca	$\frac{85000000}{\left(\frac{AOIwidth1+AOIwidth2}{10}\right)+15}$
3	Base	$\frac{85000000}{\left(\frac{AOIwidth1+AOIwidth2+AOIwidth3}{2}\right)+15}$
	Medium	$\frac{85000000}{\left(\frac{AOIwidth1+AOIwidth2+AOIwidth3}{4}\right)+15}$
	Full	$\frac{85000000}{\left(\frac{AOIwidth1+AOIwidth2+AOIwidth3}{8}\right)+15}$
	Deca	$\frac{85000000}{\left(\frac{AOIwidth1+AOIwidth2+AOIwidth3}{10}\right)+15}$

Number of AOI	CL Configuration	Line Rate Formula (Hz)
4	Base	$\frac{85000000}{\left(\frac{AOIwidth1 + AOIwidth2 + AOIwidth3 + AOIwidth4}{4}\right) + 15}$
	Medium	$\frac{85000000}{\left(\frac{AOIwidth1 + AOIwidth2 + AOIwidth3 + AOIwidth4}{2}\right) + 15}$
	Full	$\frac{85000000}{\left(\frac{AOIwidth1 + AOIwidth2 + AOIwidth3 + AOIwidth4}{8}\right) + 15}$
	Deca	$\frac{85000000}{\left(\frac{AOIwidth1 + AOIwidth2 + AOIwidth3 + AOIwidth4}{10}\right) + 15}$

Table 9: 66 MHz Camera Link Clock Rate. Maximum Line Rates of 100 kHz TDI and 200 kHz Area.

1	Base	$\frac{66000000}{\left(\frac{AOIwidth1}{2}\right) + 15}$
	Medium	$\frac{66000000}{\left(\frac{AOIwidth1}{4}\right) + 15}$
	Full	$\frac{66000000}{\left(\frac{AOIwidth1}{8}\right) + 15}$
	Deca	$\frac{66000000}{\left(\frac{AOIwidth1}{10}\right) + 15}$
2	Base	$\frac{66000000}{\left(\frac{AOIwidth1 + AOIwidth2}{2}\right) + 15}$
	Medium	$\frac{66000000}{\left(\frac{AOIwidth1 + AOIwidth2}{4}\right) + 15}$
	Full	$\frac{66000000}{\left(\frac{AOIwidth1 + AOIwidth2}{8}\right) + 15}$
	Deca	$\frac{66000000}{\left(\frac{AOIwidth1 + AOIwidth2}{10}\right) + 15}$

3	Base	$\frac{66000000}{\left(\frac{AOIwidth1 + AOIwidth2 + AOIwidth3}{2}\right) + 15}$
	Medium	$\frac{66000000}{\left(\frac{AOIwidth1 + AOIwidth2 + AOIwidth3}{4}\right) + 15}$
	Full	$\frac{66000000}{\left(\frac{AOIwidth1 + AOIwidth2 + AOIwidth3}{8}\right) + 15}$
	Deca	$\frac{66000000}{\left(\frac{AOIwidth1 + AOIwidth2 + AOIwidth3}{10}\right) + 15}$
4	Base	$\frac{66000000}{\left(\frac{AOIwidth1 + AOIwidth2 + AOIwidth3 + AOIwidth4}{2}\right) + 15}$
	Medium	$\frac{66000000}{\left(\frac{AOIwidth1 + AOIwidth2 + AOIwidth3 + AOIwidth4}{4}\right) + 15}$
	Full	$\frac{66000000}{\left(\frac{AOIwidth1 + AOIwidth2 + AOIwidth3 + AOIwidth4}{8}\right) + 15}$
	Deca	$\frac{66000000}{\left(\frac{AOIwidth1 + AOIwidth2 + AOIwidth3 + AOIwidth4}{10}\right) + 15}$

Set Exposure Time

To set the camera's exposure time, use the **Exposure Time** parameter—a member of the Camera Controls set. This feature is only available when the **Exposure Mode** parameter is set to **Timed**. The allowable exposure range is from 4 µs to 3,000 µs, dependent on the value of the internal line rate.

GenICam parameters:
Camera Controls > Exposure Time (Timed Exposure Mode) > 4 µs to 3,000 µs.

Control Gain and Black Level

The cameras provide gain and black level adjustments in the digital domain for the CMOS sensor. The gain and black level controls can make small compensations to the acquisition in situations where lighting varies and the lens iris cannot be easily adjusted. The user can evaluate gain and black level by using CamExpert.

The parameters that control gain and black level are grouped together in the Camera Controls set.

Camera Controls	
Black Level	Apply a digital addition after an FPN correction: ± 1/8 of available range. For example in 12-bit mode the available range is -512 to +511.
Gain	Set the gain as an amplification factor applied to the video signal across all pixels: 1x to 10x.

Set Image Size

To set the height of the image, and therefore the number of lines to scan, use the parameters grouped under the Image Format Control set.

Image Format Control	
Control the size of the transmitted image	
Width	Width of the image. Read only.
Height	Height of the image in lines. Read only.
Pixel Format	Mono 8, Mono 10, or Mono 12 bit depth to Camera Link.
Test Image Selector	Select an internal test image: Off Ramp A5 Each Tap Fixed All 1365 All 1

Set Baud Rate

The baud rate sets the speed (in bits per second—bps) of the serial communication port and is available as part of the Serial Port Control parameters.

Serial Port Control		
Action	**Parameter**	**Options**
Control the baud rate used by the camera's serial port	Baud Rate	9600 (factory default) 19200 57600 115200 230400* 460800* 921600* Note: During connection CamExpert automatically sets the camera to maximum allowable baud. *A Px8 or equivalent frame grabber is required in order to achieve these baud

		rates.
Number of bits per character used in the serial port	Data Size	8
Parity of the serial port	Parity	None
Number of stop bits per character used in the serial port	Number of Stop Bits	1

Pixel Format

Use the Pixel Format feature, found in the **Image Format Control** set, to select the format of the pixel to use during image acquisition as either Mono 8, Mono 10, or Mono 12 bit depth.

Image Format Control	
Parameter	**Description**
Pixel Format	Mono 8* Mono 10 Mono 12 *Only available format for Full and Deca Camera Link configurations.

Camera Direction Control

Found in the **Camera Control > Direction Control** set of features. Note: This feature is only available when in TDI mode.

Note: the **Sensor Shift** features are not available when the camera is in low or tall pixel sensitivity modes.

Camera Control > Direction Control	
Parameter	**Description**
Scan Direction Source	When in TDI stages 2 or Area mode, this command lets you select the **Internal** or **external direction control**. Use this feature to accommodate object direction change on a web and to mount the camera "upside down."
Scan Direction	Read the current direction.

Camera Direction

When in TDI mode or Area mode you can select either forward or reverse camera direction. Selectable direction accommodates object direction change on a web and allows you to mount the camera "upside down".

Note that the example here assumes the use of a lens (which inverts the image).

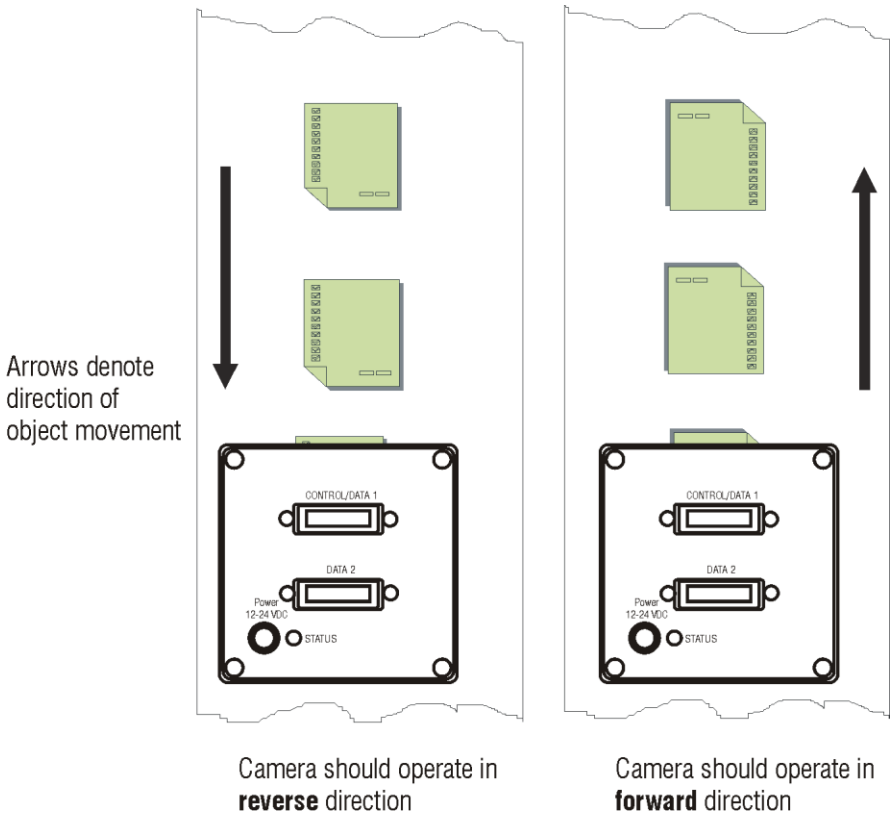


Figure 21: Object Movement and Camera Direction Example using a Lens

Pixel Readout Direction (Mirroring Mode)

Set the tap readout from left to right or from right to left. This feature is especially useful if you want to mount the camera "upside down."

Image Format Control	
Parameter	**Description**
Line Mirroring	Off: All pixels are read out from left to right. On: All pixels are read out from right to left.

Resetting the Camera

The feature **Camera Reset**, part of the **Transport Layer** set, resets the camera. The camera resets with the default settings, including a baud rate of 9600.

Transport Layer	
Parameter	**Description**
Camera Reset	Resets the camera and puts in the default settings, including a 9600 baud rate.

Calibrating the Camera

Important Note: to ensure best results, the conditions under which you calibrate the camera (e.g. temperature and illumination) should be as close to the actual operating conditions as possible. .

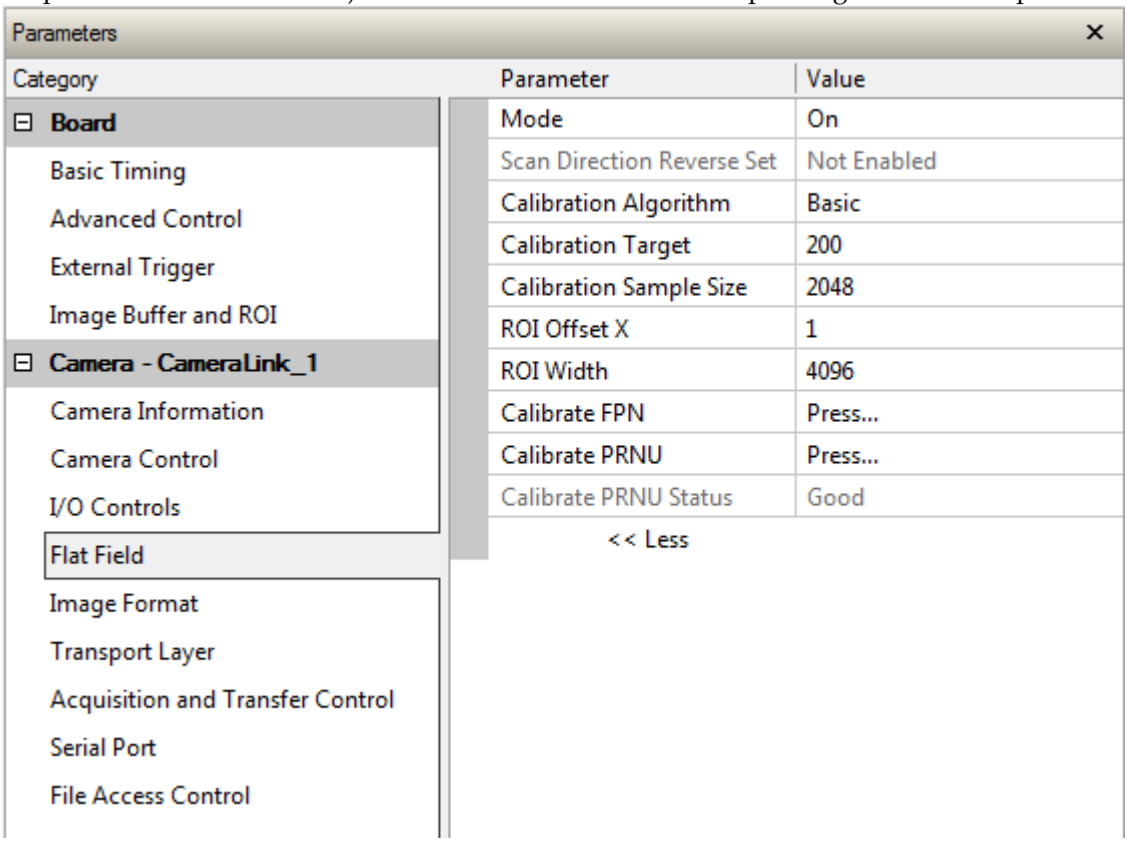


Figure 22: Flat Field Calibration in CamExpert

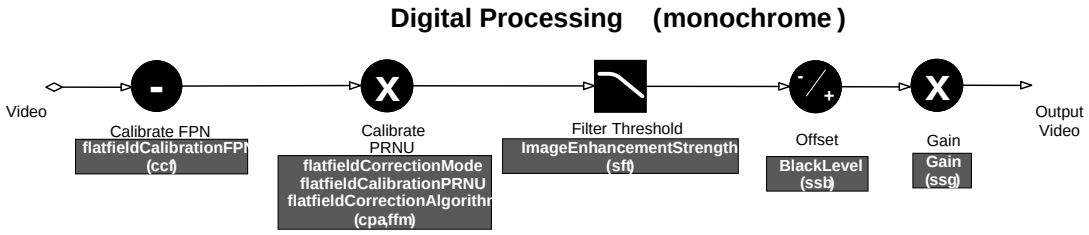


Figure 23: Camera Calibration Process.

Calibration

The goal of calibration is to produce a uniform, white balanced and, if required, color corrected image at the desired level out of the camera when it is imaging a uniform white object, using the optical setup of the user's application.

The user should configure the camera to use the EXSYNC and exposure timing they desire plus adjust the light level for normal operation. The lens should be at the desired magnification, aperture and be in focus. As the white reference located at the object plane will be in focus, any features on its surface (e.g. dust, scratches) will end up in the calibration profile of the camera. To avoid this, use a clean white plastic or ceramic material, not paper. Ideally, the white object should move during the calibration process as the averaging process of the camera will diminish the effects on any small variation in the white reference.

The user may wish to start the calibration process by evaluating the characteristics of their setup with no calibration enabled. This can be readily achieved by disabling FPN, PRNU & color correction coefficients, setting white balance red, green and blue gains to one, and the system gain to one.

Begin by adjusting the system gain until the peak intensity of the three colors is at the desired DN level. You may want to use the white balance gains to adjust the peak of each color to be a similar DN value, but this is not necessary. Before proceeding any further, it is desirable to complete an FPN calibration. This is best performed using a lens cap to ensure no light gets into the camera. Once complete, a PRNU calibration can be performed using a target value you want all the pixels to achieve. This target value can be higher or lower than the peak values you observed while initially setting up the camera. Once PRNU calibration is complete, it will take several seconds, all three colors should be at the target value, white balance gains will have been adjusted to suit the cameras optimum setup for a balanced white output, and the correction coefficient will be enabled. The system gain will remain as originally set. The coefficient and gain parameters, timing and control configuration etc can be stored in any one of eight user sets and automatically retrieved at power up or by user selection. If a color correction matrix is desired, the user can download and save a color correction file derived from the process described above.
Note: For the color correction to be effective, the camera should have a white balanced output when color correction is off.

CamExpert has a default timeout of 20 seconds per command, which is too short for the FFC calibration to run fully. You can change the default timeout by setting a command line argument in the short-cut:

- Right click on the short-cut in the start menu and select properties.
- Add –timeout 60 to increase the command timeout to 60 seconds (See below). **Note** that you must include a character space between the closing quotation mark in the target and the hyphen before the timeout value.
- Repeat for desktop short-cut

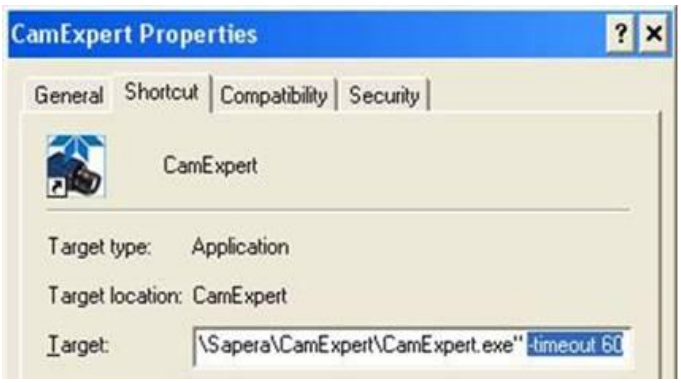


Figure 24: Setting the camera's timeout value

1. Flat Field

This Flat Field set contains a number of features that are used to correct image distortion due to lens vignetting and uneven illumination.

Note:
1. Flat field coefficients consist of an offset and gain for each pixel.
2. These are the first user corrections applied to the image.
3. The flat field coefficients are saved and loaded with the user set.

Flat Field	
Parameter	**Description**
flatfieldCorrectionMode	1. Off – Flat field correction coefficients are not applied. 2. On – Flat field correction coefficients are applied. 3. Initialize – Sending this value will reset all current coefficients (offsets to 0 and gains to 1x).
flatfieldCorrectionAlgorithm	1. Basic – Direct calculation of coefficients based on current average line values and target. 2. LowPass – A low pass filter is first applied to the current average line values before calculating the coefficients. Use this algorithm if the calibration target is not uniform white or it s not possible to defocus the image. Because of the low pass filter this algorithm is not able to correct pixel-to-pixel variations and so it is preferable to use the "Basic" algorithm if possible.
flatfieldCalibrationTarget	1. After calibration all pixels will be scaled to output this level 2. Range depends on pixel format: • 8 bit: 0 to 255 DN • 10 bit: 0 to 1023 DN • 12 bit: 0 to 4095 DN
flatfieldCalibrationSampleSize	1. Number of lines to average when calibrating 2. 2048 or 4096
flatfieldCalibrationROIOffsetX	1. Together with "flatfieldCalibrationROIWidth" specifies the range of pixels to be calibrated. Pixel coefficients outside this range are not changed. It is possible to calibrate different regions sequentially.

flatfieldCalibrationROIWidth	
flatfieldCalibrationFPN	1. Save average line (of "flatfieldCalibrationSampleSize" rows). This is the first user correction applied – it is subtracted from each line. 2. This feature may not be of use to many users as the camera already subtracts true "dark current", but it may be useful for some to provide a per pixel offset correction. 3. Range 0 to 511 DN, 12 bit 4. Default value is 0 DN for each pixel
flatfieldCalibrationPRNU	1. Use "flatfieldCorrectionAlgorithm" to calculate the per pixel gain to achieve the specified target output. 2. Range 0 to 15.9998x 3. Default 1x

2. Contrast Enhancement

Use the Offset and Gain features to maximize the use of the output dynamic range (especially when pixel format is less than 12 bits). Typical use is to subtract minimum pixel value expected and then gain up maximum pixel value to approach full scale.

Offset

1. Single value added to each pixel
2. Range -512 to 511 DN, scaled down according to pixel format
3. Positive values may be used to measure dark noise

Gain

1. Floating point digital multiplier applied to each pixel
2. Range 1x to 10x

Appendix A: GenICam Commands

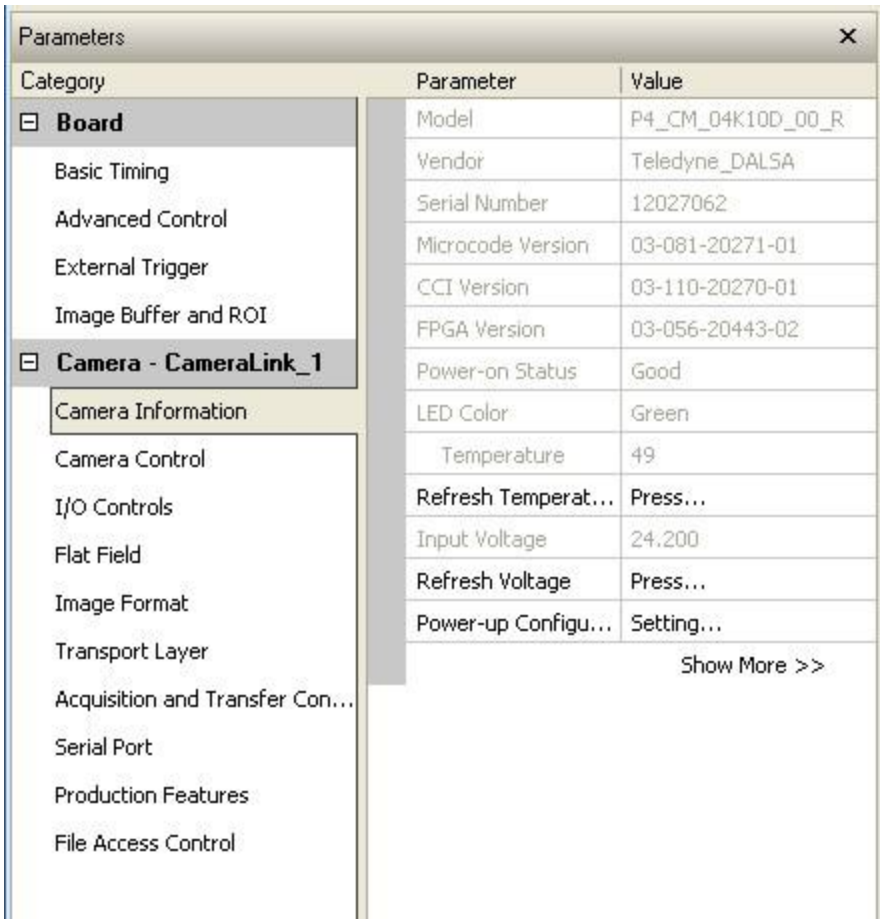
This appendix lists the available GenICam camera features. Access these features using the CamExpert interface.

Features listed in the description table but tagged as *Invisible* are typically reserved for Teledyne DALSA Support or third party software usage, and not typically required by end user applications.

A note on the CamExpert examples shown here: The examples shown for illustrative purposes and may not entirely reflect the features and parameters available from the camera model used in your application.

Camera Information Category

Camera information can be retrieved via a controlling application. Parameters such as camera model, firmware version, etc. are read to uniquely identify the connected P4 device. These features are typically read-only.
The Camera Information Category groups information specific to the individual camera. In this category the number of features shown is identical whether the view is Beginner, Expert, or Guru.
Features listed in the description table but tagged as *Invisible* are usually for Teledyne DALSA or third party software usage—not typically needed by end user applications.



Camera Information Feature Descriptions

The following table describes these parameters along with their view attributes and in which version of the device the feature was introduced. Additionally the Device Version column will indicate which parameter is a member of the DALSA Features Naming Convention (using the tag **DFNC**), verses the GenICam Standard Features Naming Convention (SFNC not shown).

The Device Version number represents the camera software functional group, not a firmware revision number.

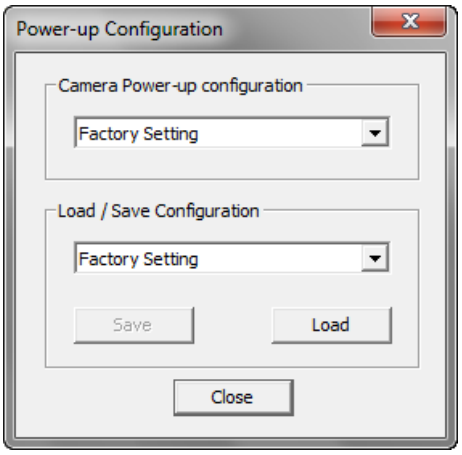
Display Name	Feature	Description	Device Version & View
Model Name	DeviceModelName	Displays the device model name. (RO)	1.00 Beginner
Vendor Name	DeviceVendorName	Displays the device vendor name. (RO)	1.00 Beginner
Device Version	DeviceVersion	Displays the device version. This tag will also highlight if the firmware is a beta or custom design. (RO)	1.00 Beginner
Manufacturer Info	DeviceManufacturerInfo	This feature provides extended manufacturer information about the device. (RO)	1.00 Beginner

Display Name	Feature	Description	Device Version & View
Firmware Version	DeviceFirmwareVersion	Displays the currently loaded firmware version number. Firmware files have a unique number and have the .cbf file extension. (RO)	1.00 Beginner
Serial Number	DeviceID	Displays the device's factory set camera serial number. (RO)	1.00 Beginner
Device User ID	DeviceUserID	Feature to store user-programmable identifier of up to 15 characters. The default factory setting is the camera serial number. (RW)	1.00 Beginner
Power-up Configuration Selector	UserSetDefaultSelector	Selects the camera configuration set to load and make active on camera power-up or reset. The camera configuration sets are stored in camera non-volatile memory. (RW)	1.00 Beginner
Factory Setting	**Default**	**Load factory default feature settings**	
UserSet1	UserSet1	Select the user defined configuration UserSet 1 as the Power-up Configuration.	
UserSet2	UserSet2	Select the user defined configuration UserSet 2 as the Power-up Configuration	
UserSet3	UserSet3	Select the user defined configuration UserSet 3 as the Power-up Configuration	
UserSet4	UserSet4	Select the user defined configuration UserSet 4 as the Power-up Configuration.	
UserSet5	UserSet5	Select the user defined configuration UserSet 5 as the Power-up Configuration.	
UserSet6	UserSet6	Select the user defined configuration UserSet 6 as the Power-up Configuration.	
UserSet7	UserSet7	Select the user defined configuration UserSet 7 as the Power-up Configuration.	
UserSet8	UserSet8	Select the user defined configuration UserSet 8 as the Power-up Configuration.	
User Set Selector	UserSetSelector	Selects the camera configuration set to load feature settings from or save current feature settings to. The Factory set contains default camera feature settings. (RW)	1.00 Beginner
Factory Setting	**Default**	**Select the default camera feature settings saved by the factory**	
UserSet 1	UserSet1	Select the User-defined Configuration space UserSet1 to save to or load from features settings previously saved by the user.	
UserSet 2	UserSet2	Select the User-defined Configuration space UserSet2 to save to or load from features settings previously saved by the user.	
UserSet3	UserSet3	Select the User-defined Configuration space UserSet3 to save to or load from features settings previously saved by the user.	

Display Name	Feature	Description	Device Version & View
UserSet4	UserSet4	Select the User-defined Configuration space UserSet4 to save to or load from features settings previously saved by the user.	
UserSet5	UserSet5	Select the User-defined Configuration space UserSet5 to save to or load from features settings previously saved by the user.	
UserSet6	UserSet6	Select the User-defined Configuration space UserSet6 to save to or load from features settings previously saved by the user.	
UserSet7	UserSet7	Select the User-defined Configuration space UserSet7 to save to or load from features settings previously saved by the user.	
UserSet8	UserSet8	Select the User-defined Configuration space UserSet8 to save to or load from features settings previously saved by the user.	
Power-on User Set	UserSetDefaultSelector	Allows the user to select between the factory set and 1 to 8 user sets to be loaded at power up	1.00 Beginner
Current User Set	UserSetSelector	Points to which user set (1-8) or factory set that is loaded or saved when the UserSetLoad or UserSetSave command is used	1.00 Beginner
Load Configuration	UserSetLoad	Loads the camera configuration set specified by the User Set Selector feature, to the camera and makes it active. (W)	1.00 Beginner
Save Configuration	UserSetSave	Saves the current camera configuration to the user set specified by the User Set Selector feature. The user sets are located on the camera in non-volatile memory. (W)	1.00 Beginner
Device Built-In Self Test Status	deviceBISTStatus	Determine the status of the device using the 'Built-In Self Test'. Possible return values are device-specific. (RO)	1.00 DFNC Beginner
LED Color	deviceLEDColorControl	Displays the status of the LED on the back of the camera. (RO)	1.00 DFNC Beginner
Temperature	DeviceTemperature	Displays the internal operating temperature of the camera. (RO)	1.00 DFNC Beginner
Refresh Temperature	refreshTemperature	Press to display the current internal operating temperature of the camera.	1.00 DFNC Beginner
Input Voltage	deviceInputVoltage	Displays the input voltage to the camera at the power connector (RO)	1.00 DFNC Beginner
Refresh Voltage	refreshVoltage	Press to display the current input voltage of the camera at the power connector	1.00 DFNC Beginner

Display Name	Feature	Description	Device Version & View
License Key	securityUpgrade		1.00 DFNC Guru

Camera Configuration Selection Dialog



CamExpert provides a dialog box which combines the features to select the camera power up state and for the user to save or load a camera state from Genie memory.

Camera Power-up Configuration

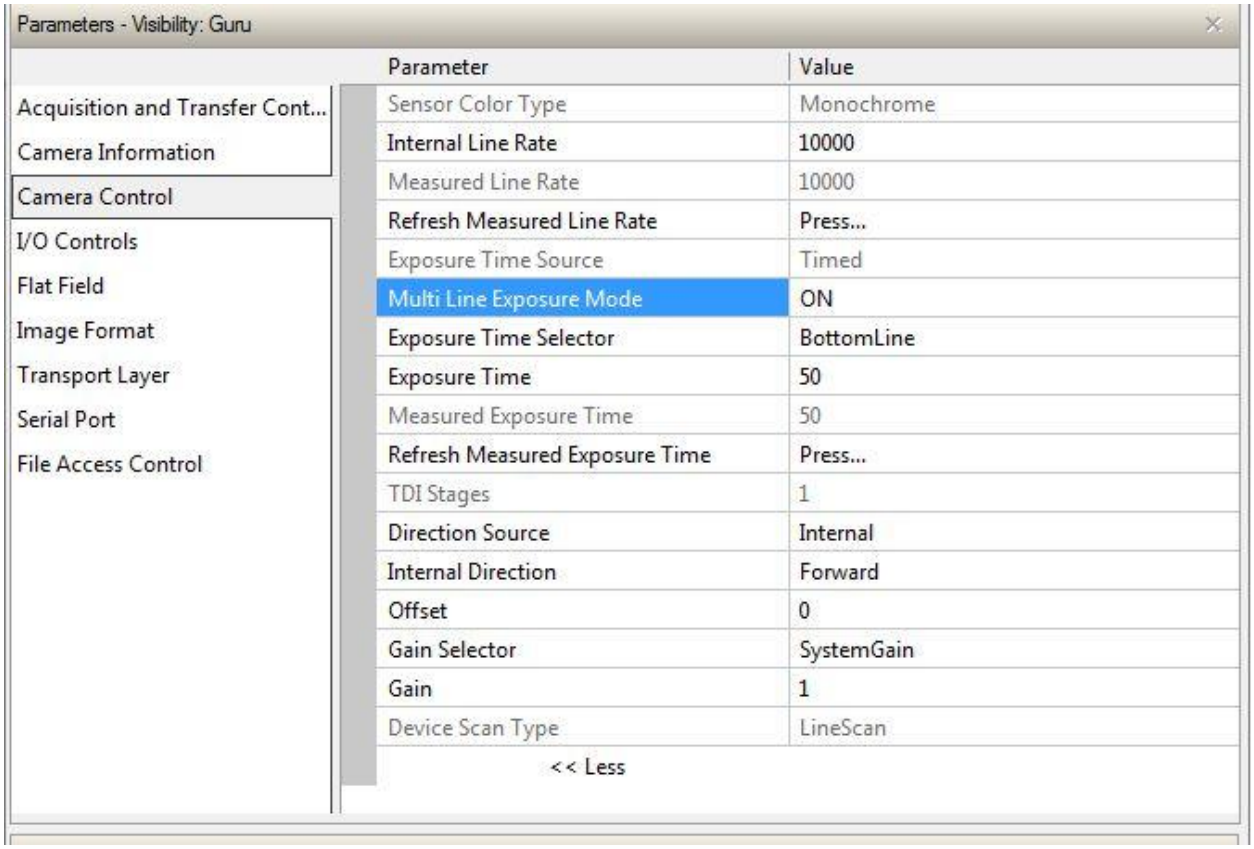
The first drop list selects the camera configuration state to load on power-up (see feature *UserSetDefaultSelector*). The user chooses from one factory data set or one of two possible user saved states.

User Set Configuration Management

The second drop list allows the user to change the camera configuration anytime after a power-up (see feature *UserSetSelector*). To reset the camera to the factory configuration, select *Factory Setting* and click Load. To save a current camera configuration, select User Set 1 to 8 and click Save. Select a saved user set and click Load to restore a saved configuration.

Camera Control Category

The P4 camera controls, as shown by CamExpert, groups sensor specific parameters. This group includes controls for line rate, exposure time, scan direction, and gain. Parameters in gray are read only, either always or due to another parameter being disabled. Parameters in black are user set in CamExpert or programmable via an imaging application.



Camera Control Feature Descriptions

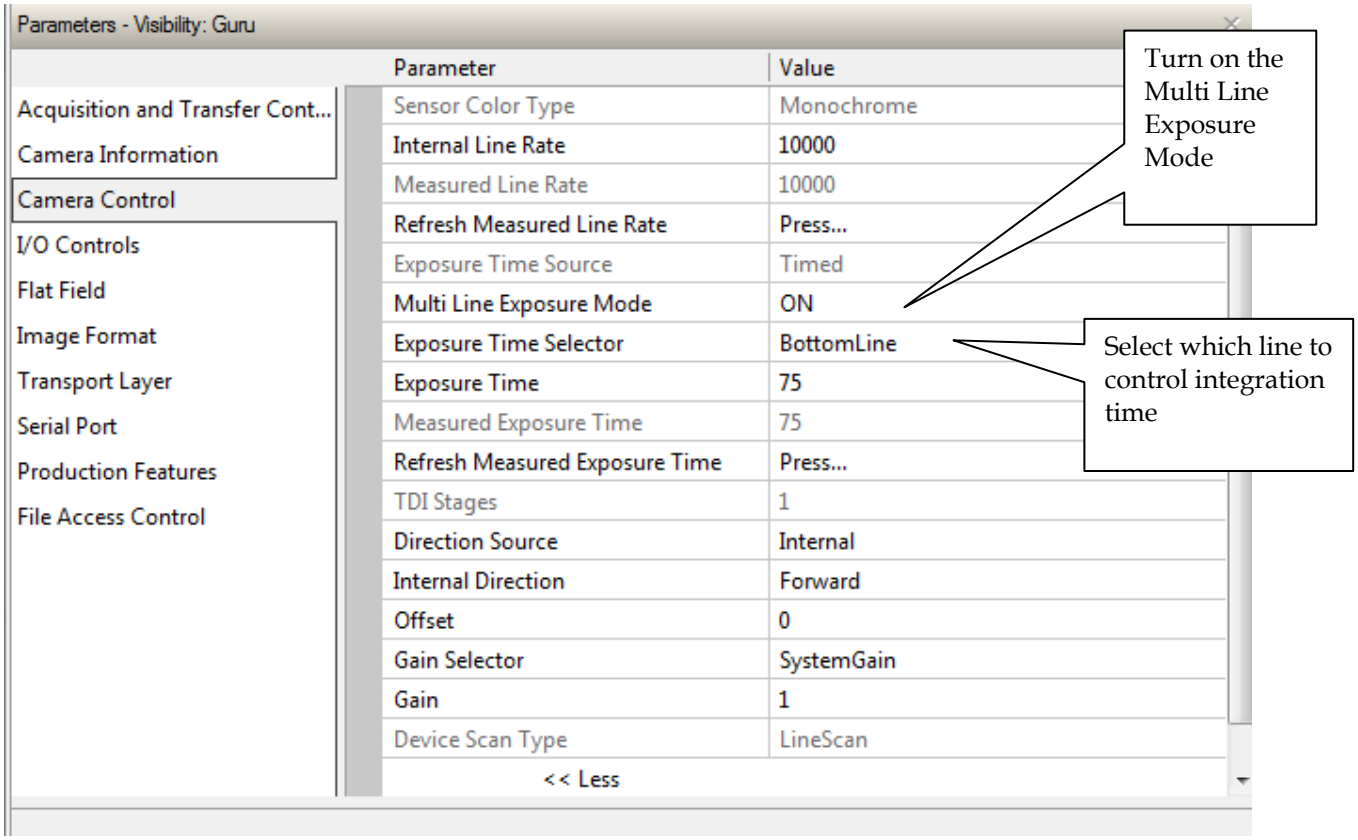
The following table describes these parameters along with their view attribute and minimum camera firmware version required. Additionally the firmware column will indicate which parameter is a member of the DALSA Features Naming Convention (DFNC), verses the GenICam Standard Features Naming Convention (SFNC not shown). The Device Version number represents the camera software functional group, not a firmware revision number.

Display Name	Feature	Description	Device Version & View
Internal Line Rate	AcquisitionLineRate	Specifies the camera internal line rate, in Hz when Trigger mode set to internal. Note that any user entered value is automatically adjusted to a valid camera value.	1.00 Beginner
Measured Line Rate	measureLineRate	Specifies the line rate provided to the camera by either internal or external source (RO)	1.00 Beginner
Refresh measured line rate	refreshMeasureLineRate	Press to show the current line rate provided to the camera by either internal or external sources	1.00 Beginner
Exposure Time Source Timed Trigger Width	ExposureMode Timed TriggerWidth	Sets the operation mode for the camera's exposure (or shutter). (RO) The exposure duration time is set using the Exposure Time feature and the exposure starts with a LineStart event. Uses the width of the trigger signal pulse to control the exposure duration.	1.00 Beginner
TDI Stages 1 2	sensorTDIStageSelection 1 2	Selects the number of lines to be imaged Single Line Two lines summed together	1.00 Beginner DFNC
Multi Line Exposure Mode ON OFF	multiLineExposureMode ON OFF	Selects Multi Line exposure mode For independent exposure control of each line For TDI stage = 1, 2 or Area mode	1.00 Beginner DFNC
Exposure Time Selector All Top Line Bottom Line	exposureTimeSelector All TopLine BottomLine	Used to select where ExposureTime is applied to. Both lines get equal exposure time Allows the top line to have exposure time set Allows the bottom line to have the exposure time set.	1.00 Beginner DFNC
Exposure Time	ExposureTime	Sets the exposure time (in microseconds) when the Exposure Mode feature is set to Timed.	1.00 Beginner
Measured Exposure Time	measureExposureTime	Specifies the exposure time provided to the camera by either internal or external source (RO)	1.00 Beginner
Refreshed measured exposure time	refreshMeasureExposureTime	Press to display the current exposure time provided to the camera.	1.00 Beginner

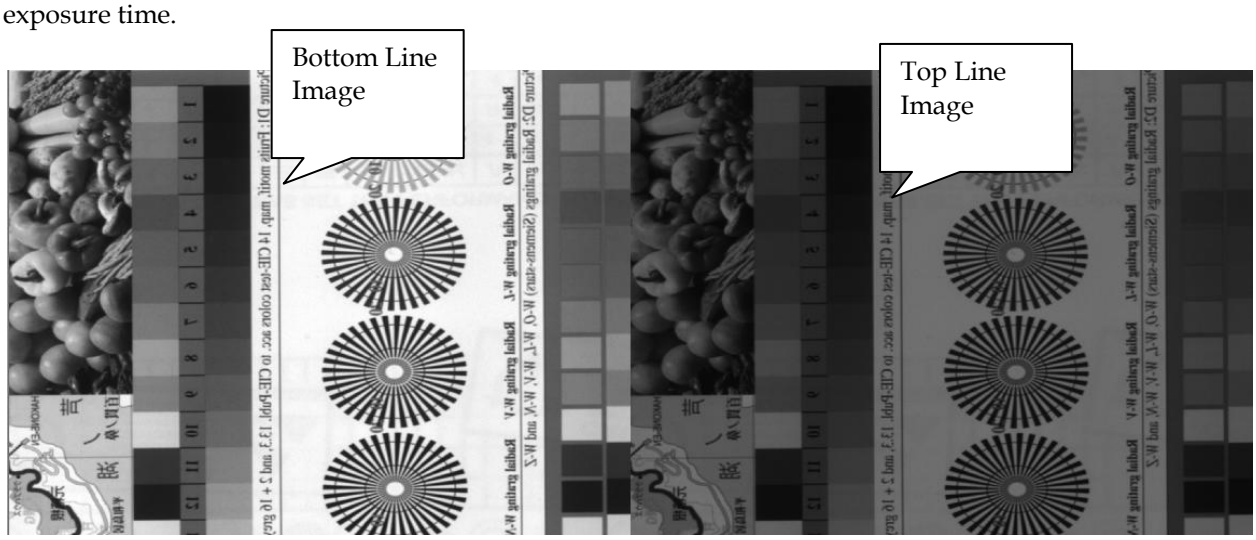
Display Name	Feature	Description	Device Version & View
Direction Source	sensorScanDirectionSource Internal External	 Direction determined by value of SensorScanDirection Direction control determined by value on CC3	1.00 Beginner
Internal Direction	sensorScanDirection Forward Reverse	When ScanDirectionSource set to Internal, determines the direction of the scan	1.00 Beginner
Gain Selector	GainSelector	Selects to which line that gain will be applied	1.00 Beginner
System Gain	SystemGain	Gain will be applied to top and bottom lines equally	
Top Line	TopLine	Gain will be applied to the top line only	
Bottom Line	BottomLine	Gain will be applied to the bottom line only	
Gain	Gain	Sets the selected gain as an amplification factor applied to the image.	1.00 Beginner
Offset	BlackLevel	Controls the black level as an absolute physical value. This represents a DC offset applied to the video signal, in DN (digital number) units.	1.00 Beginner
Device Scan Type	DeviceScanType	Selects mode of operation of the camera between Line scan mode and Area scan mode	1.00 Beginner
Line Scan	LineScan		
Area Scan	AreaScan		

Multi-Exposure Mode

The multi-exposure mode allows for the simultaneous exposure of each line of the sensor with two different exposure times or gains. The result is an increase in the dynamic range of the image.



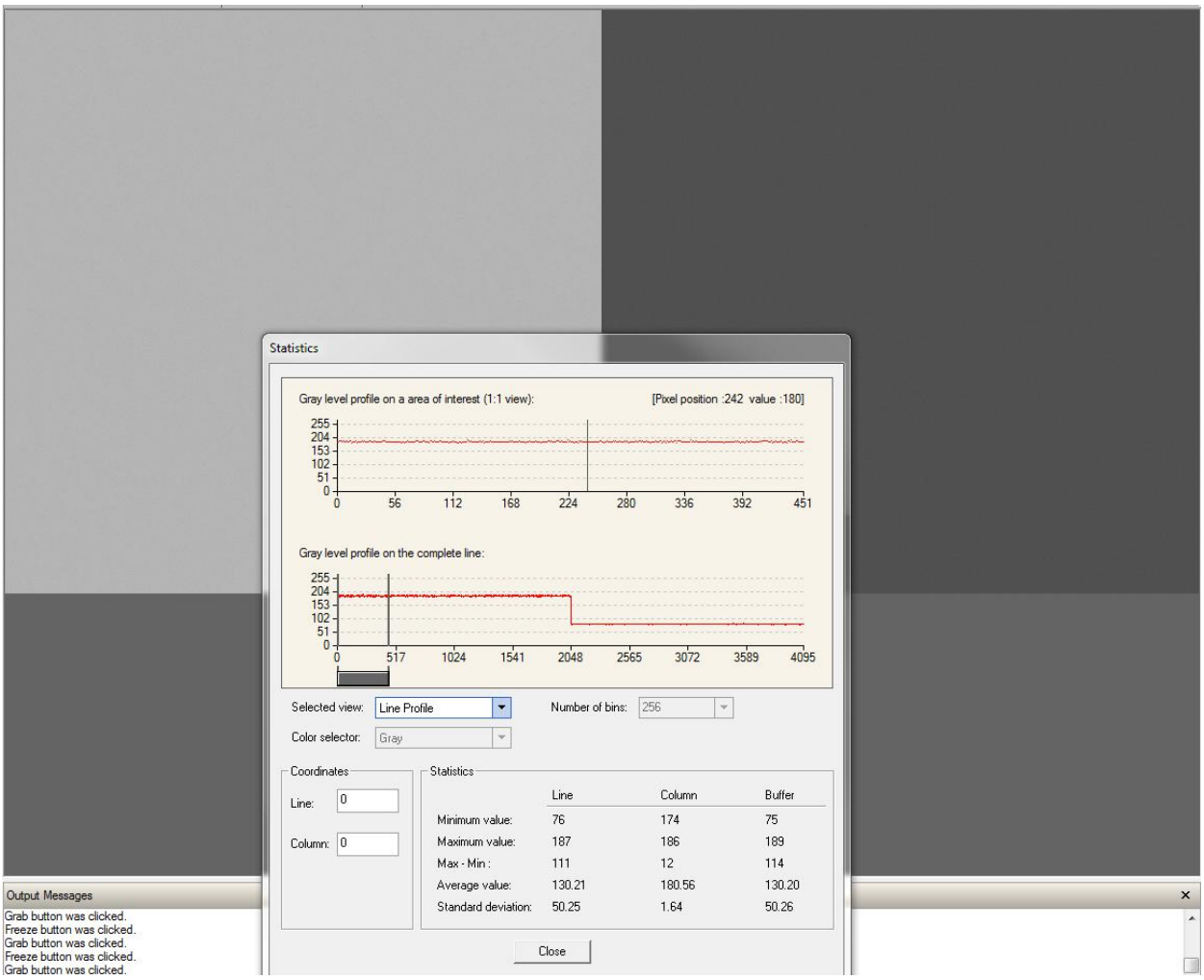
Note: to initiate multi-exposure mode, set TDI stage = 1 (stg 1) and ensure that the camera is in line scan mode (dst 0). The exposure time selector (ses) command is used to select which line to apply the exposure time.



In the above example image the left and right half side of the image are identical except for the amount of exposure time applied.

Flat-Field Calibration of Image in Multi-Exposure Mode

Performing a flat-field calibration while in multi-exposure mode results in the camera automatically setting both lines of the sensor to the same integration time. Both lines will be flat-fielded to the target value provided. After the flat-field calibration has completed the integration and gain values are reset to the lines that they were set to prior to the flat-field request.



In the above example the flat-field target was set to 200 DN, based on the image on the left-hand side. The integration time for the image on the right was automatically set the same as the image on the left during the flat-field process. After the flat-field process had completed, the image on the right-hand side had its selected integration time restored to its pre-calibration value, which is why it appears darker than the left side.

Flat-Field Region of Interest

While in multi-exposure mode, setting up a flat-field region of interest results the same region of interest coordinates to be applied to both lines.

Multi-Exposure Output Format

While in multi-exposure mode the width of the output will double. A 2k camera will output a 4k image with the left half of the image being the bottom line and the right half being the top line.

Output AOI when in Multi-Exposure Mode

The same output AOI will be applied to both the top and bottom lines while in multi-exposure mode.

Line Rate

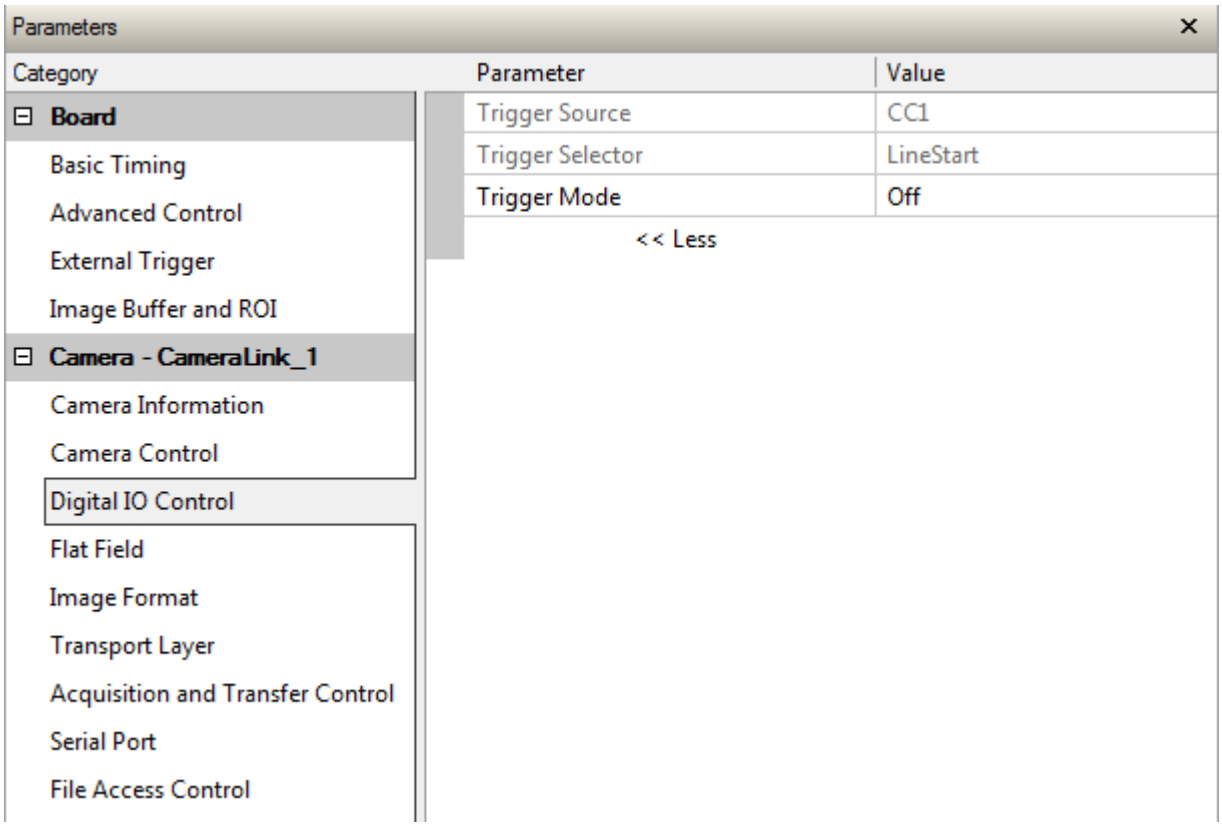
While in multi-exposure mode the maximum line rate available is limited by the longest exposure time.

Exposure Time Limitation

The exposure time of the two lines must differ by greater than 1 µs.

Digital I/O Control Feature Descriptions

The P4 Digital I/O control category, as organized by CamExpert, groups together the sensor specific parameters. This group includes the controls for line rate, exposure time, scan direction, and gain. Parameters in gray are read-only, either always or due to another parameter being enabled or disabled. Parameters in black are user set in CamExpert or programmable via an imaging application.

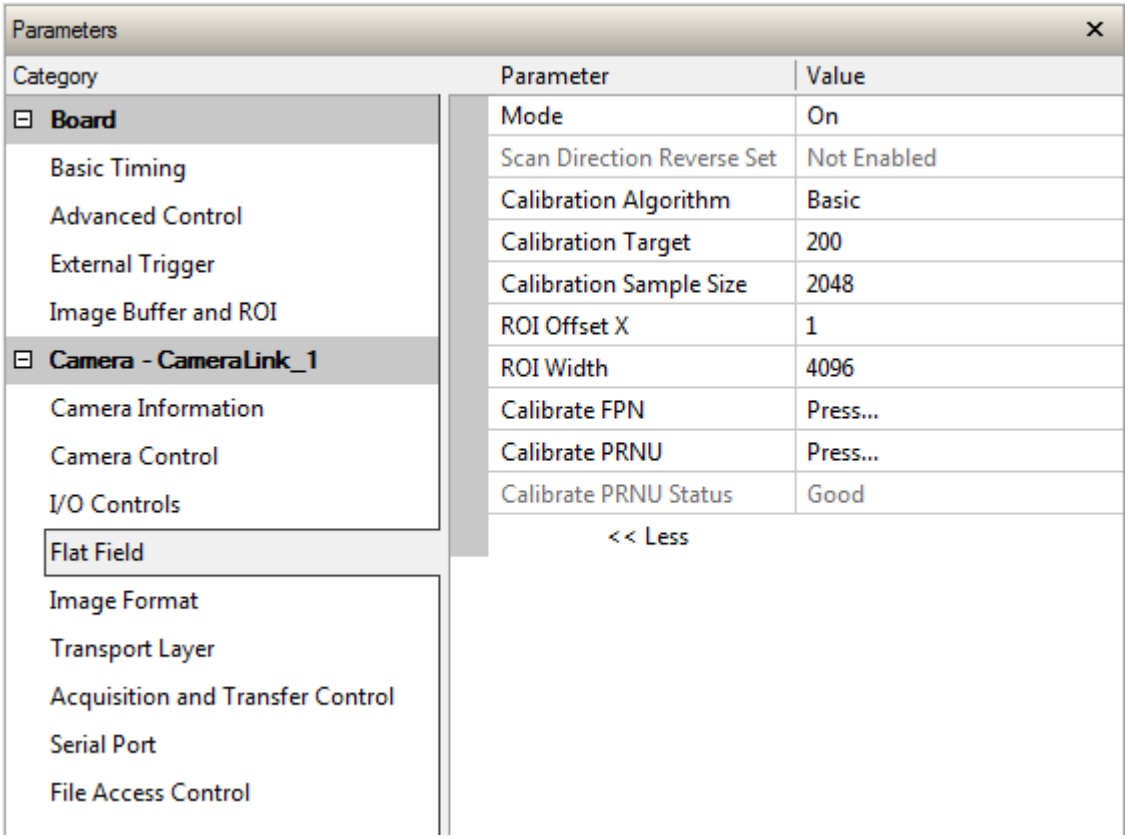


The following table describes the digital I / O control parameters along with their view attributes and the minimum camera firmware version required. Additionally, the firmware column indicates which parameter is a member of the DALSA Features Naming Convention (DFNC), verses the GenICam Standard Features Naming Convention (SFNC not shown). The Device Version number represents the camera software functional group, not a firmware revision number.

Display Name	Feature	Description	Device Version & View
Trigger Source	Trigger Source	Defines the source of external trigger (RO)	1.00 DFNC Beginner
Trigger Selector	Trigger Selector	Defines what the trigger initiates (RO)	1.00 DFNC Beginner
Trigger Mode	Trigger Mode	Determines the source of trigger to the camera, internal or external (CC1)	1.00 DFNC Beginner

Flat Field Category

The P4 Flat Field controls, as shown by CamExpert, group parameters used to configure camera pixel format, and image cropping. Additionally a feature control to select and output an internal test image simplifies the process of setting up a camera without a lens.
Parameters in gray are read only, either always or due to another parameter being disabled. Parameters in black are user set in CamExpert or programmable via an imaging application.
Features listed in the description table but tagged as *Invisible* are usually for Teledyne DALSA or third party software usage—not typically needed by end user applications.



Flat Field Control Feature Description

The following table describes these parameters along with their view attribute and minimum camera firmware version required. Additionally the firmware column will indicate which parameter is a member of the DALSA Features Naming Convention (DFNC), verses the GenICam Standard Features Naming Convention (SFNC not shown).
The Device Version number represents the camera software functional group, not a firmware revision number.

Display Name	Feature	Description	Device Version & View
Mode	flatfieldCorrectionMode		1.00
Off	Off	FPN and flat field coefficients disabled.	Beginner
On	On	FPN and flat field coefficients enabled.	DFNC
Initialize	Initialize	Reset all FPN to 0 and all flat field coefficients to 1.	
ScanDirectionControlled	ScanDirectionControlled	Different user set loaded depending on direction.	

Display Name	Feature	Description	Device Version & View
Select flatfield Correction Scan Direction Reverse Set	flatfieldScanDirectionReverseSet	When flatfieldCorrectionMode is set to ScanDirectionControlled this feature selects the UserSEt (1 to8) which will be used for the reverse scan direction.	1.00 Beginner DFNC
Calibration Algorithm	flatfieldCorrectionAlgorithm	Selection between two different flat field algorithms.	1.00 Beginner DFNC
Basic	Basic	Direct calculation of coefficients based on average line values and target. First each color is flat fielded to its peak value and then the color gains are used to achieve the target.	
LowPass	LowPass	A low pass filter is first applied to the average line values before calculating the coefficients. Use this algorithm if the calibration target is not uniformly white or it is not possible to defocus the image. Because of the low pass filter this algorithm is not able to correct pixel-to-pixel variations and so it is preferable to use the "Basic" algorithm.	
Calibration Target	flatfieldCalibrationTarget	Set a value between 0 and 255 to which the flat field algorithm will taget the image to.	1.00 Beginner DFNC
Calibration Sample Size	flatfieldCalibrationSampleSize	Sets the number of lines to be averaged during a flat field calibration	1.00 Beginner DFNC
Lines_2048 Lines_4096	Lines_2048 Lines_4096		
ROI Offset X	flatfieldCalibrationROIOffsetX	Set the starting point of a region of interest where a flat field calibration will be performed	1.00 Beginner DFNC
ROI Width	flatfieldCalibrationROIWidth	Sets the width of the region on interest where a flat field calibration will be performed	1.00 Beginner DFNC
Calibrate FPN	flatfieldCalibrationFPN	Initiates the FPN calibration process	1.00 Beginner DFNC
Calibrate PRNU	flatfieldCalibrationPRNU	Initiates the PRNU or Flatfield process	1.00 Beginner DFNC

Region of Interest (ROI)

The ROI feature is related to flat field calibration. It is important to specify an ROI when the object being imaged has areas that have black, non illuminated areas such as beyond the edge of a film that is front illuminated, or is saturated, again beyond the edge of a film but in this case bright field back illuminated. The ROI feature allows from one to four specific regions of the pixel line to be specified where flat field calibration will take place. Pixel data outside the ROI will not be used when performing flat field calibration.

Image Format Control Category

The P4 Image Format controls, as shown by CamExpert, groups parameters used to configure camera pixel format, image cropping, and the test pattern.
Parameters in gray are read only, either always or due to another parameter being disabled. Parameters in black are user set in CamExpert or programmable via an imaging application.
Features listed in the description table but tagged as *Invisible* are usually for Teledyne DALSA or third party software usage—not typically needed by end user applications.

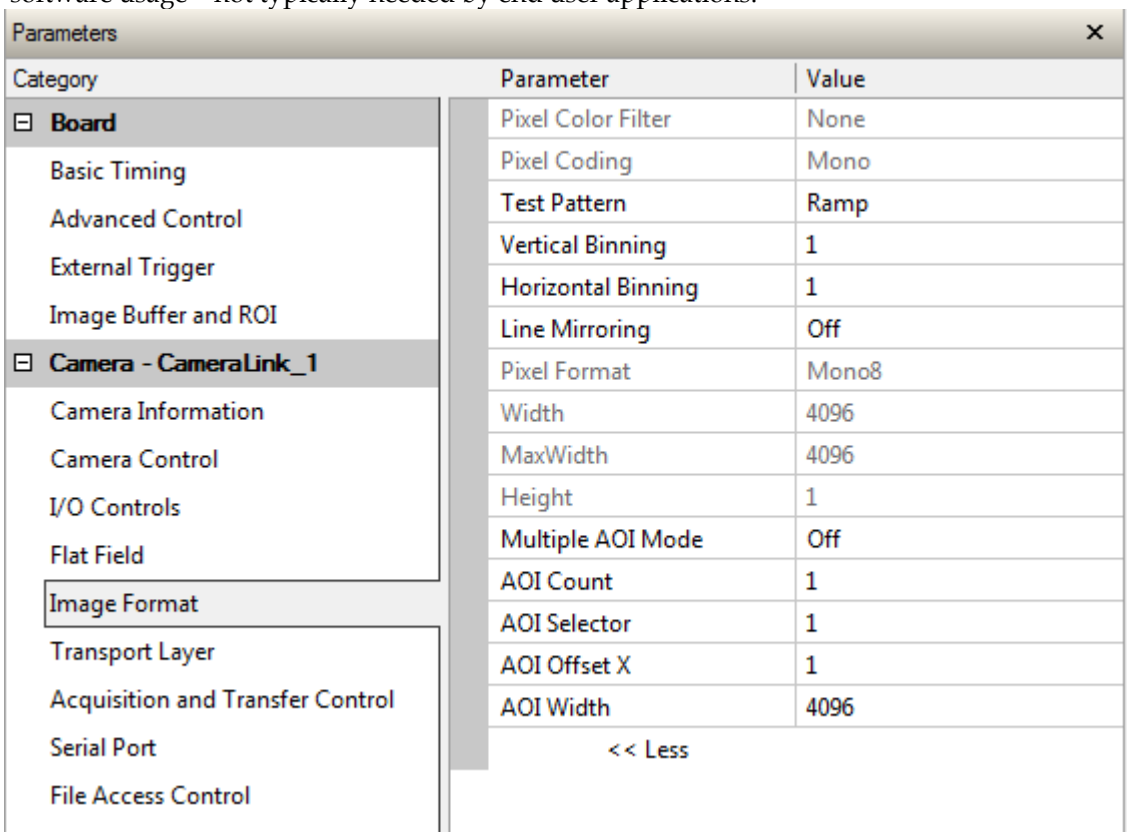


Image Format Control Feature Description

The following table describes these parameters along with their view attribute and minimum camera firmware version required. Additionally the firmware column will indicate which parameter is a member of the DALSA Features Naming Convention (DFNC), verses the GenICam Standard Features Naming Convention (SFNC not shown).
The Device Version number represents the camera software functional group, not a firmware revision number.

Display Name	Feature	Description	Device Version & View
Test Pattern	TestImageSelector	Selects the type of test image that is sent by the camera. Choices are either as defined by SNFC and/or as provided by the device manufacturer.	1.00 Beginner DFNC
Off	Off	Selects sensor video to be output from sensor	
Ramp	Ramp	Selects a grey scale	
Line Mirroring	ReverseX		1.00
Off	Off	Video output in normal order	Beginner
On	On	Video output in a reverse order	DFNC
Pixel Format	Pixel Format	Output image pixel coding format of the sensor.	1.00 Beginner DFNC
Width	Width	Width of the Image provided by the device (in pixels).(RO)	1.00 Beginner
Max Width	WidthMax	The maximum image horizontal dimension of the image. (RO)	1.00 Beginner
Height	Height	Height of the Image provided by the device (in lines). (RO)	1.00 Beginner
Input Pixel Size	pixelSizeInput	Size of the image input pixels, in bits per pixel. (RO)	1.00 DFNC Guru
8 Bits/Pixel	Bpp8	Sensor output data path is 8 bits per pixel.	
10 Bits/Pixel	Bpp10	Sensor output data path is 10 bits per pixel.	
12 Bits/Pixel	Bpp12	Sensor output data path is 12 bits per pixel.	
Multiple AOI Mode	multipleAOIMode	Turns on an output Area of Interest	1.00
Off	Off	Area of interest is off	Beginner
Active	Active	Area of interest is on	DFNC
Multiple AOI Count	multipleAOICount	Set the number of output area of interest 1-4	1.00 Beginner DFNC

Multiple AOI Selector	multipleAOISelector	Selects the area of interest to be setup	1.00 Beginner DFNC
AOI Offset X	multipleAOIOffsetX	Set the start of area of interest (pixels)	1.00 Beginner
AOI Width	multipleAOIWidth	Set the width of area of interest (pixels)	1.00 Beginner DFNC

Binning

Binning is the combining of two or more image sensor pixels to form a new combined pixel. A binned image using the same exposure settings as a non-binned image will show an improved signal-to-noise ratio, reduced scanning times (due to lower spatial resolution) and save as a smaller image file size compared with a non-binned image, at the expense of lower image resolution.

In 2 x 2 binning, 4 physical pixels on the sensor are combined into one image pixel. This operating mode is ideal for applications that require faster acquisition and processing times and require greater signal collection.

For this camera, the default binning value is 1 x 1,

The **Binning Vertical** and **Binning Horizontal** features in the **Image Format Control** set represents the number of horizontal pixels that will be combined (added) together.

Note: Compared to running the camera in TDI stages = 2, running the camera in 2 x 2 binning mode will result in 4x responsivity, not 2x. Any increase in output due to binning is relative to a single sensor line (TDI stage = 1).

Image Format Control	
Parameter	**Description**
Binning Vertical	This feature represents the number of vertical photo-sensitive cells that must be combined (added) together: 2. Note: TDI stages must be set to 1 before vertical binning can be changed to 2x.
Binning Horizontal	This feature represents the number of horizontal photo-sensitive cells that must be combined (added) together.

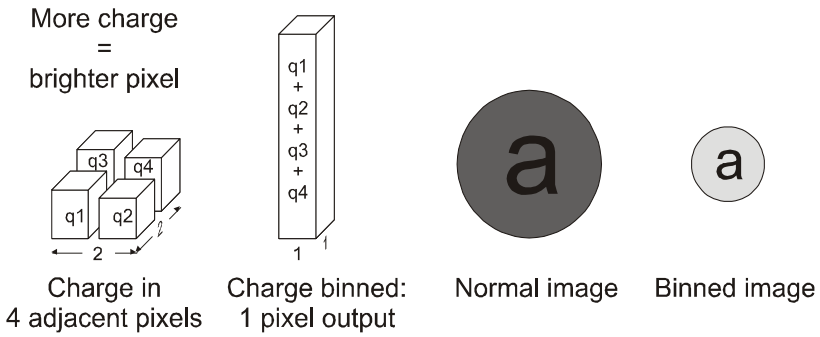


Figure 25: 2x2 Binning in Area Mode

Area of Interest (AOI) Setup

The Area of Interest (AOI) feature can be used to reduce the amount of image-data output from the camera. Use this feature when there are areas in the image that contain unneeded information.

An example where you would use this feature is in an application that is inspecting several separated lanes of objects with one camera and the image between the lanes can be ignored.

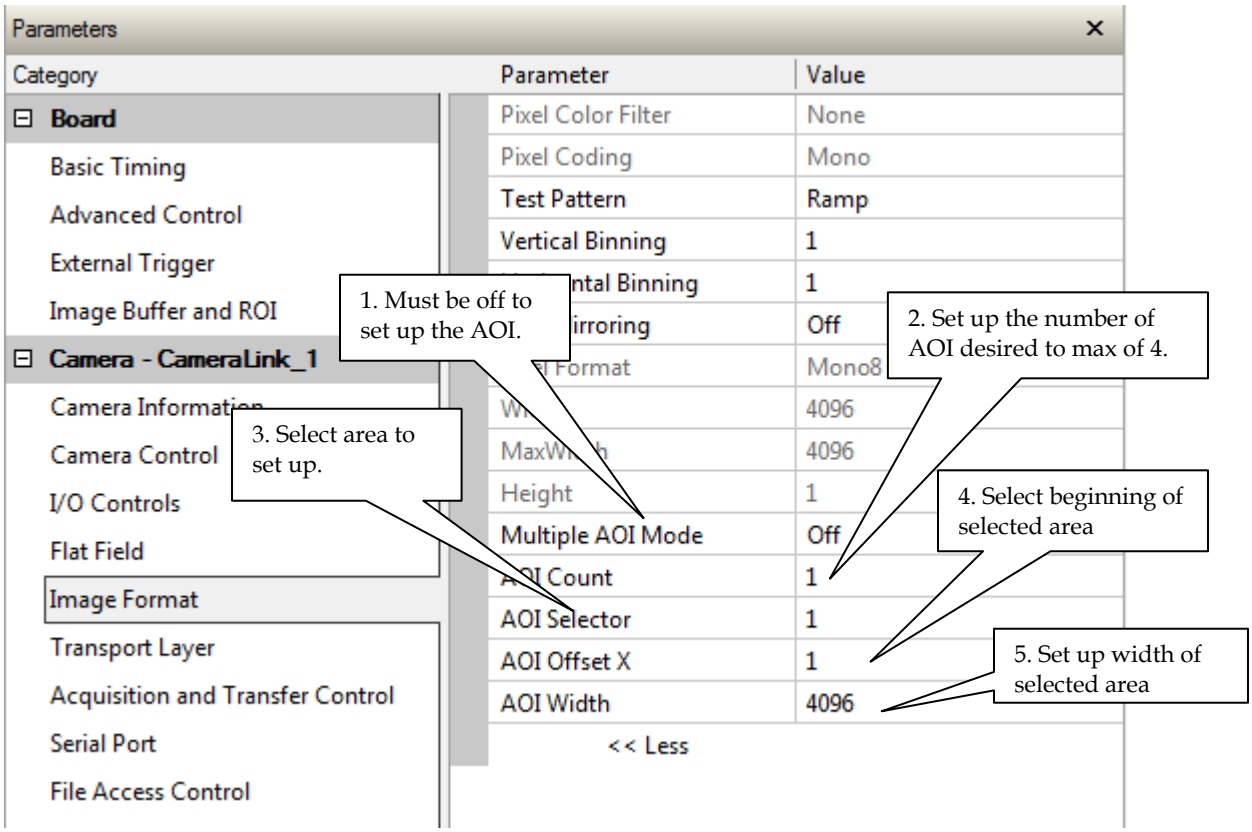
The AOI feature allows from one to four specific areas of the pixel line to be specified where image data will be output. Since the AOI feature reduces the amount of data output, this has the additional benefit of allowing the cameras to operate at higher EXSYNC rates when using base or medium camera link modes.

For example, in the 4k camera model, if the total number of pixels for the specified AOI`s is less than 1 K when using base Camera Link mode at 85 MHz, the maximum EXSYNC rate can be 100 kHz; versus 41 kHz if all 4 K pixels were output.

Note: The setup of AOI is always with respect to the sensor. Therefore, if you are using the mirroring mode with AOI, be aware that pixel one will be on the right side of the displayed image.

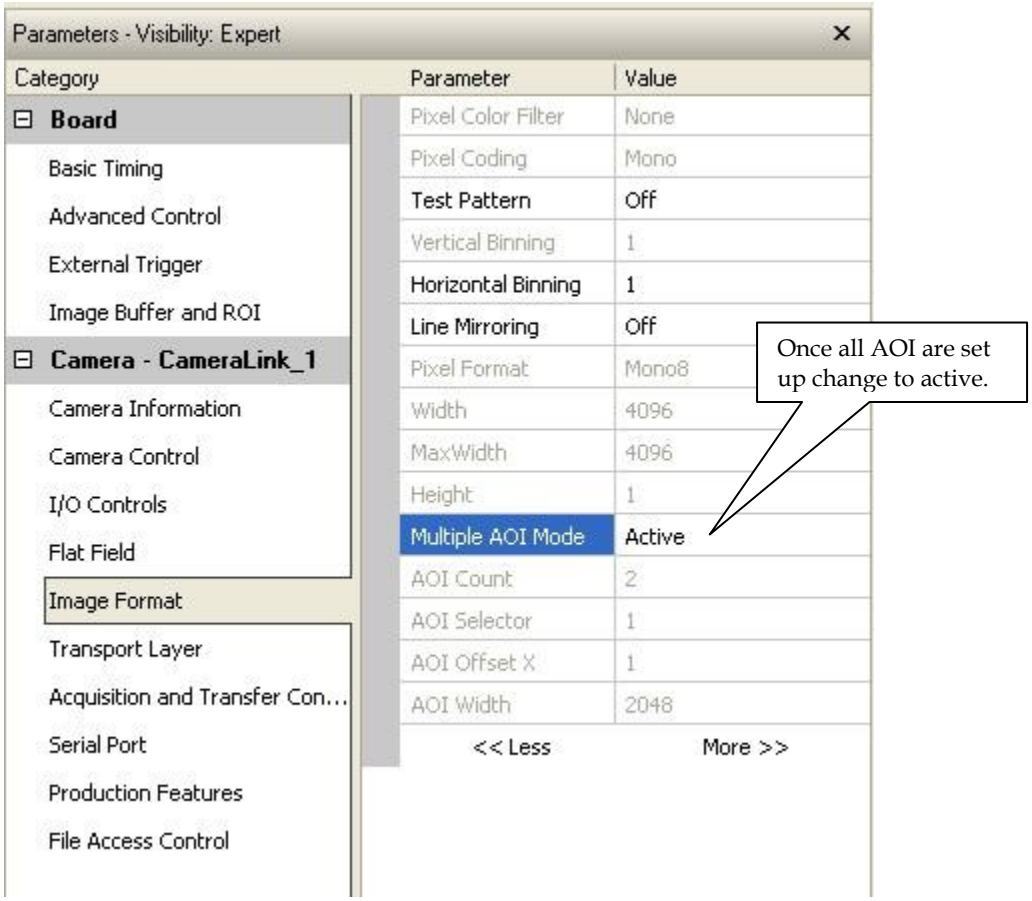
In order to set up an AOI for the camera:

1. The AOI mode must first be in the off position.
2. Use the AOI Count to select the total number of AOIs desired to a max of 4.
3. To set up each AOI individually use the AOI Selector to point to the AOI to be set up.
4. AOI Offset X is used indicate the starting pixel of the AOI.
5. AOI Width is used to indicate the width of the AOI.


Parameters
Category
Parameter
Value
Board
Basic Timing
Advanced Control
External Trigger
Image Buffer and ROI
Camera - CameraLink_1
Camera Information
Camera Control
I/O Controls
Flat Field
Image Format
Transport Layer
Acquisition and Transfer Control
Serial Port
File Access Control
Pixel Color Filter
None
Pixel Coding
Mono
Test Pattern
Ramp
Vertical Binning
1
1
Off
Mono8
4096
4096
1
Multiple AOI Mode
Off
1
AOI Selector
1
AOI Offset X
1
AOI Width
4096
<< Less
1. Must be off to set up the AOI.
2. Set up the number of AOI desired to max of 4.
3. Select area to set up.
4. Select beginning of selected area
5. Set up width of selected area

In order to initiate operation of the AOI once setup:

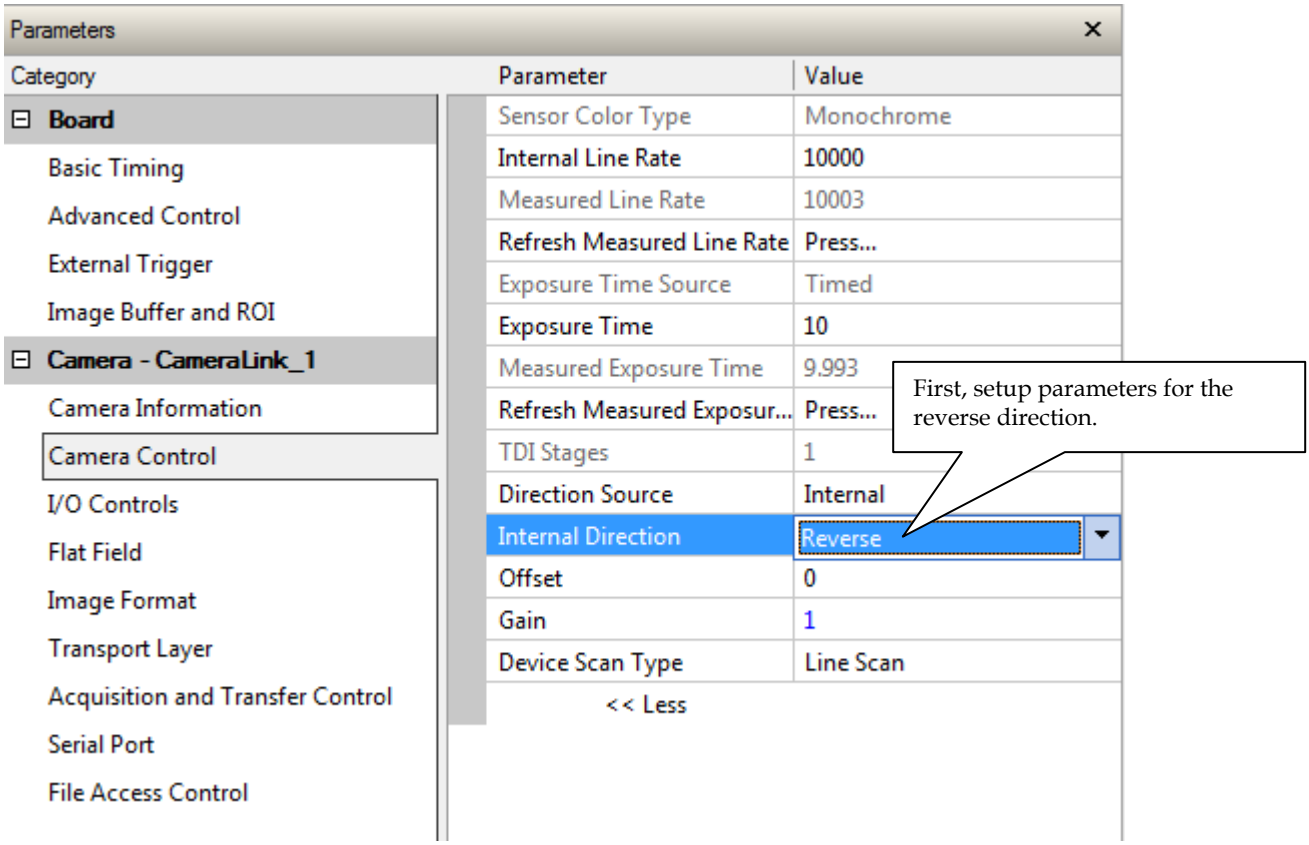
1. The AOI mode must be changed to Active.
2. Be sure to set the frame grabber image width to the sum of all AOI widths set up in the camera.



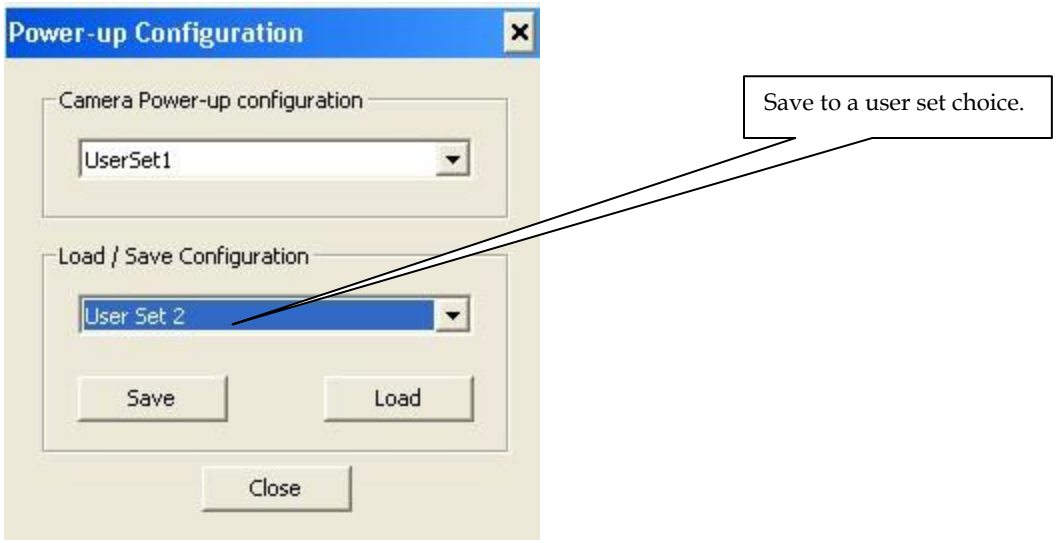
Instructions on Using the Camera Scan Direction to Control Camera Parameters

The camera is capable of adjusting camera parameters on-the-fly based on the scan direction of the camera. These parameters include gain, flat field coefficients, white balance and exposure time.

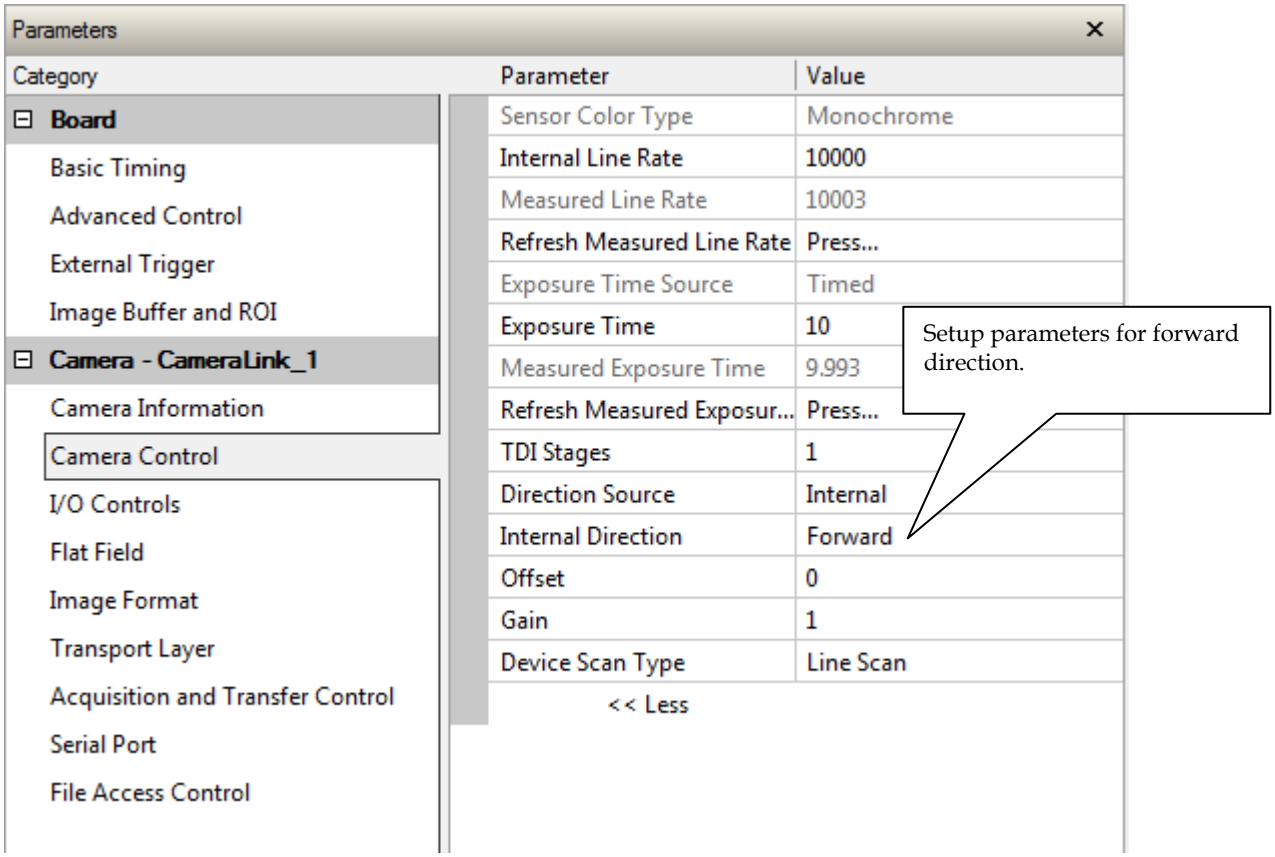
1. The first step is to put the camera in the reverse direction. This can be done using a reverse signal through CC3 and the Direction Source set to external or by having the Direction Source set to Internal and the Internal Direction set to reverse.
2. Set up all the desired parameters, including flat field corrections.



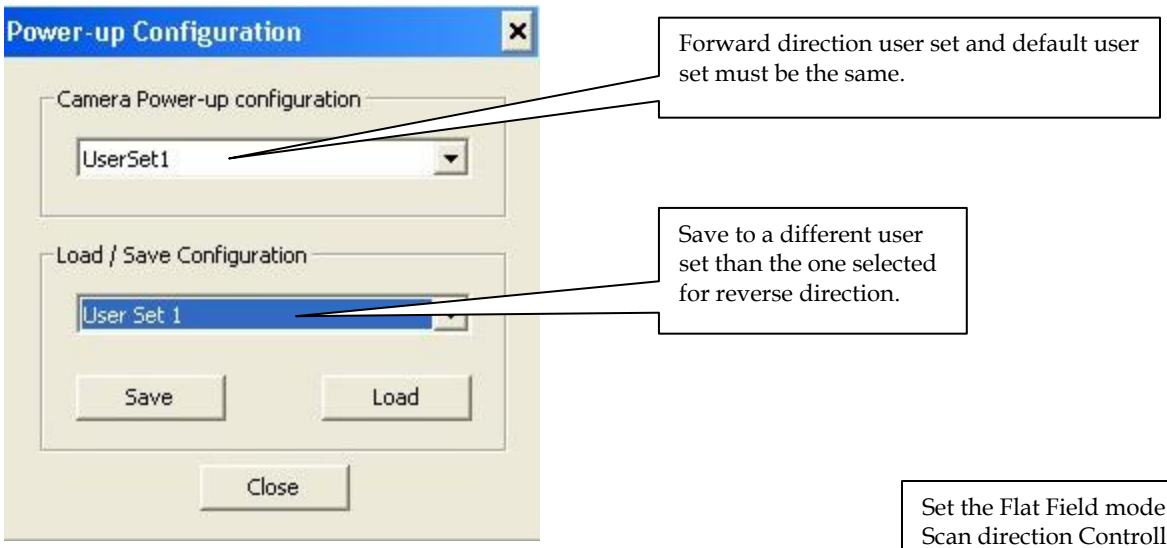
3. Save the camera parameters to a User set other than the default user set.



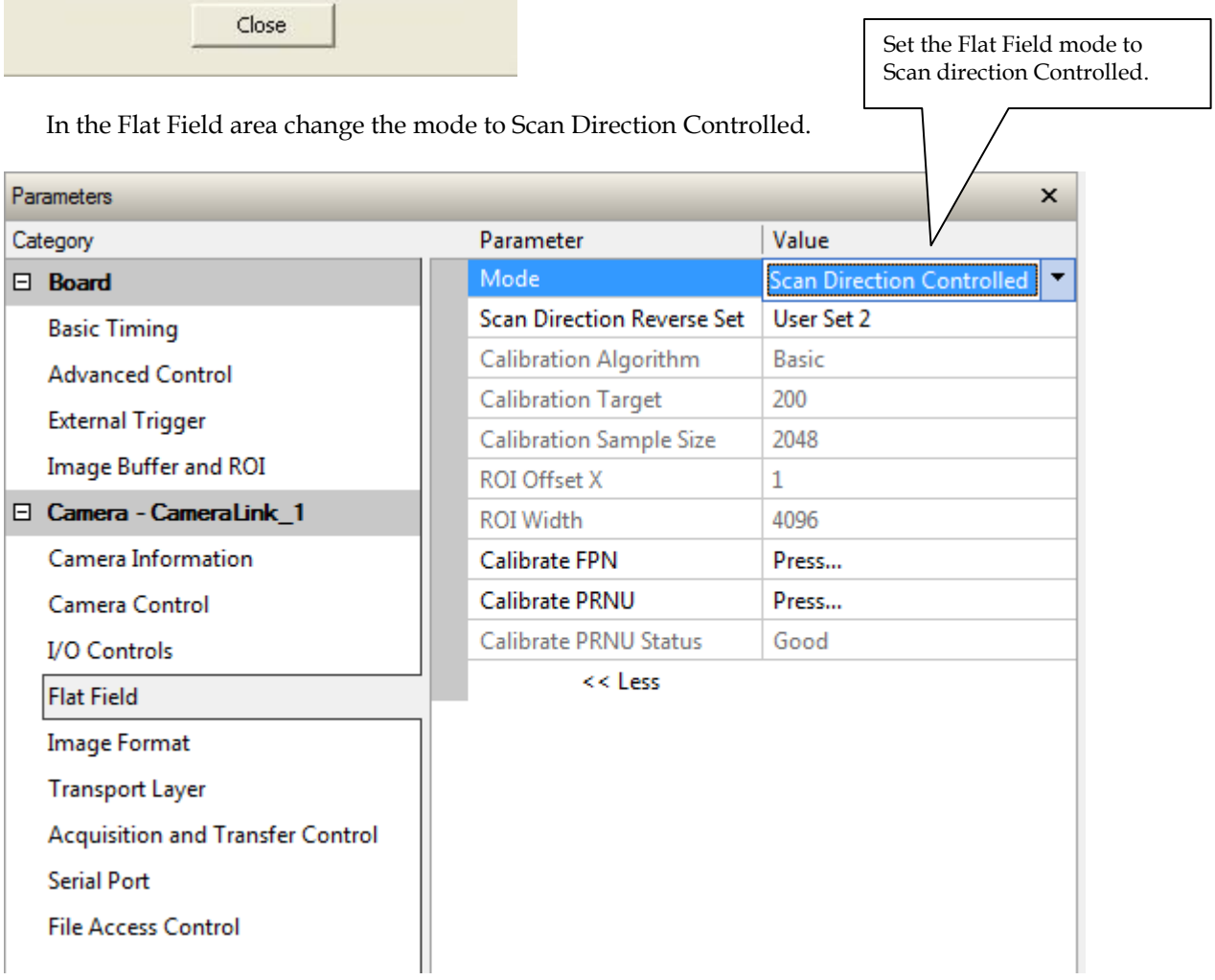
4. The next step is to put the camera in the forward direction. This can be done using a forward signal through CC3 and the Direction Source set to external or by having the Direction Source set to Internal and the Internal Direction set to forward.
5. Set up all the desired parameters including doing a flat field.



6. Save the camera set to User Set other than the saved to for the reverse direction. The forward direction user set and the default user set must be the same.


Power-up Configuration
Camera Power-up configuration
UserSet1
Load / Save Configuration
User Set 1
Save
Load
Close
Forward direction user set and default user set must be the same.
Save to a different user set than the one selected for reverse direction.

In the Flat Field area change the mode to Scan Direction Controlled.

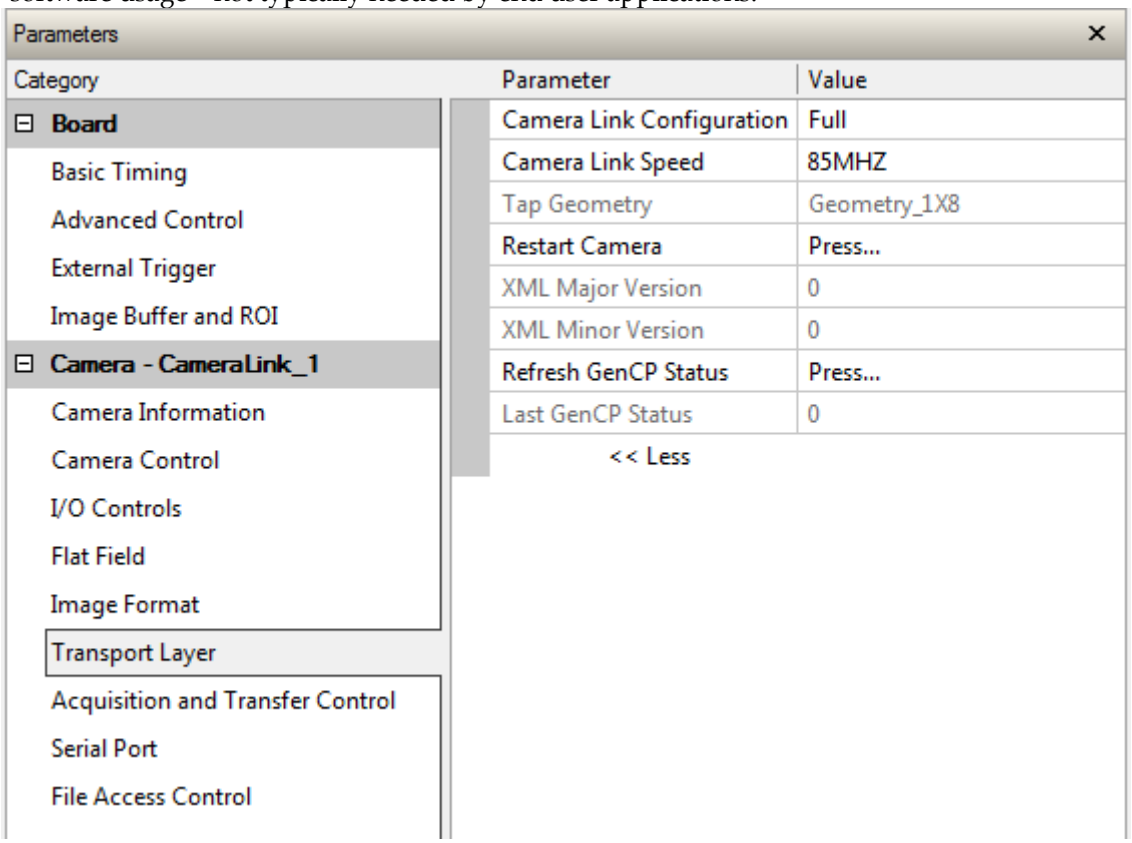


A Note on External Direction, Direction Source, and User Sets

If using external direction control through CC3 ensure that the Direction Source is both set to external and saved in the user set. Also ensure that the polarity on CC3 is set appropriately for the desired direction.

Transport Layer Control Category

Parameters in gray are read only, either always or due to another parameter being disabled. Parameters in black are user set in CamExpert or programmable via an imaging application.
Features listed in the description table but tagged as *Invisible* are usually for Teledyne DALSA or third party software usage—not typically needed by end user applications.



Transport Layer Feature Descriptions

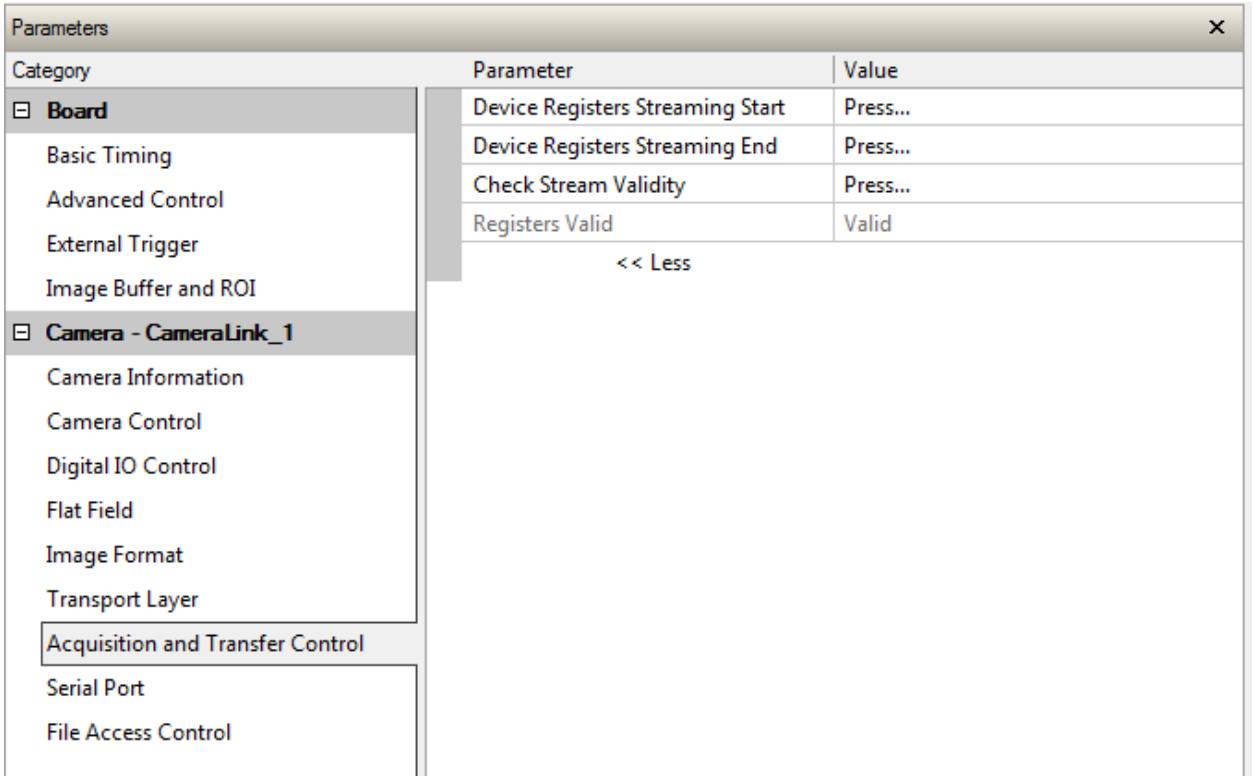
The following table describes these parameters along with their view attribute and minimum camera firmware version required. Additionally the firmware column will indicate which parameter is a member of the DALSA Features Naming Convention (DFNC), verses the GenICam Standard Features Naming Convention (SFNC not shown).

Display Name	Feature	Description	Device Version & View
Restart Camera	DeviceReset	Used to restart the camera, warm reset	1.00 Beginner DFNC
XML Major Version	DeviceManifestXMLMajorVersion	Together with DeviceManifestXMLMinorVersion specifies the GenICam™ feature description XML file version (RO)	1.00 Beginner DFNC
XML Minor Version	DeviceManifestXMLMinorVersion	Together with DeviceManifestXMLMajorVersion specifies the GenICam™ feature description XML file version (RO)	1.00 Beginner DFNC
Last GenCP Status	genCPStatus	If a feature read or write fails then Sapera only returns that it fails – read this feature to get the actual reason for the failure Returns the last error Reading this feature clears it	1.00 Beginner DFNC
Refresh GenCP Status	refreshGenCPStatus	Press to return the current status of the GenCP	1.00 Beginner
Camera Link Configuration	ClConfiguration Base Medium Full Deca	Camera Link Output configuration	1.00 Beginner
Camera Link Configuration	clDeviceClockFrequency CL85MHz CL66MHz	Set the camera link clock rate	1.00 Beginner
Tap Geometry	DeviceTapGeometry	(RO)	1.00 Beginner

Acquisition and Transfer Control Category

The P4 Acquisition and Transfer controls, as shown by CamExpert, groups parameters used to configure the optional acquisition modes of the device. Parameters in gray are read only, either always or due to another parameter being disabled. Parameters in black are user set in CamExpert or programmable via an imaging application.

Features listed in the description table but tagged as *Invisible* are usually for Teledyne DALSA or third party software usage—not typically needed by end user applications.



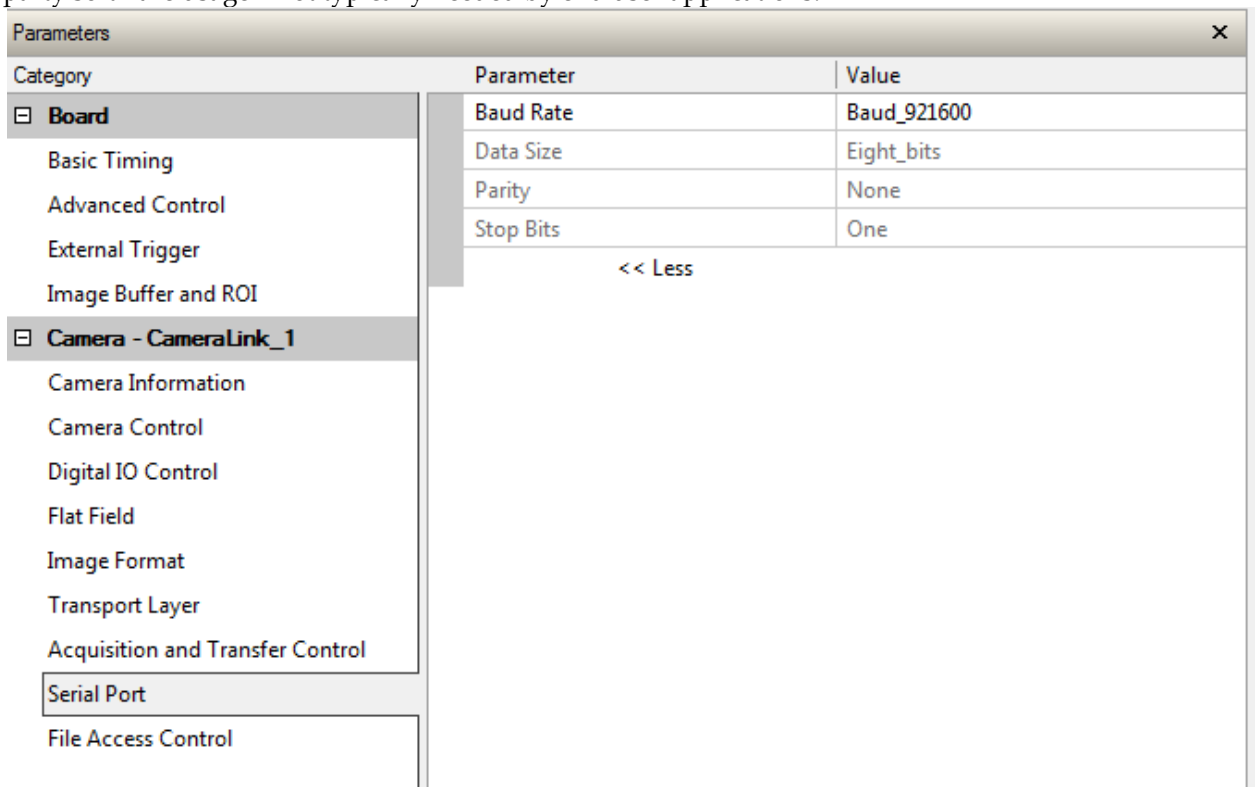
Acquisition and Transfer Control Feature Descriptions

The following table describes these parameters along with their view attribute and minimum camera firmware version required. Additionally the firmware column will indicate which parameter is a member of the DALSA Features Naming Convention (DFNC), verses the GenICam Standard Features Naming Convention (SFNC not shown).

Display Name	Feature	Description	Device Version & View
Device Registers Streaming Start	DeviceRegistersStreamingStart	Announces the start of registers streaming without immediate checking for consistency.	1.00 Beginner DFNC
Device Registers Streaming End	DeviceRegistersStreamingEnd	Announces end of registers streaming and performs validation for registers consistency before activating them.	1.00 Beginner DFNC
Check Stream Validity	DeviceRegistersCheck	Press to check the validity of the current register set.	1.00 Beginner DFNC
Registers Valid	DeviceRegistersValid	States if the current register set is valid and consistent.	1.00 Beginner DFNC

Serial Port Control Category

The Serial Port control in CamExpert allows the user to select an available camera serial port and review its settings. This section also describes the Genie TS Framework Virtual Serial Port Driver and the use of the Genie TS serial port as an interface from an Ethernet network to a serial port control system for other devices.
Features listed in the description table but tagged as *Invisible* are usually for Teledyne DALSA or third party software usage—not typically needed by end user applications.



Serial Port Control Feature Descriptions

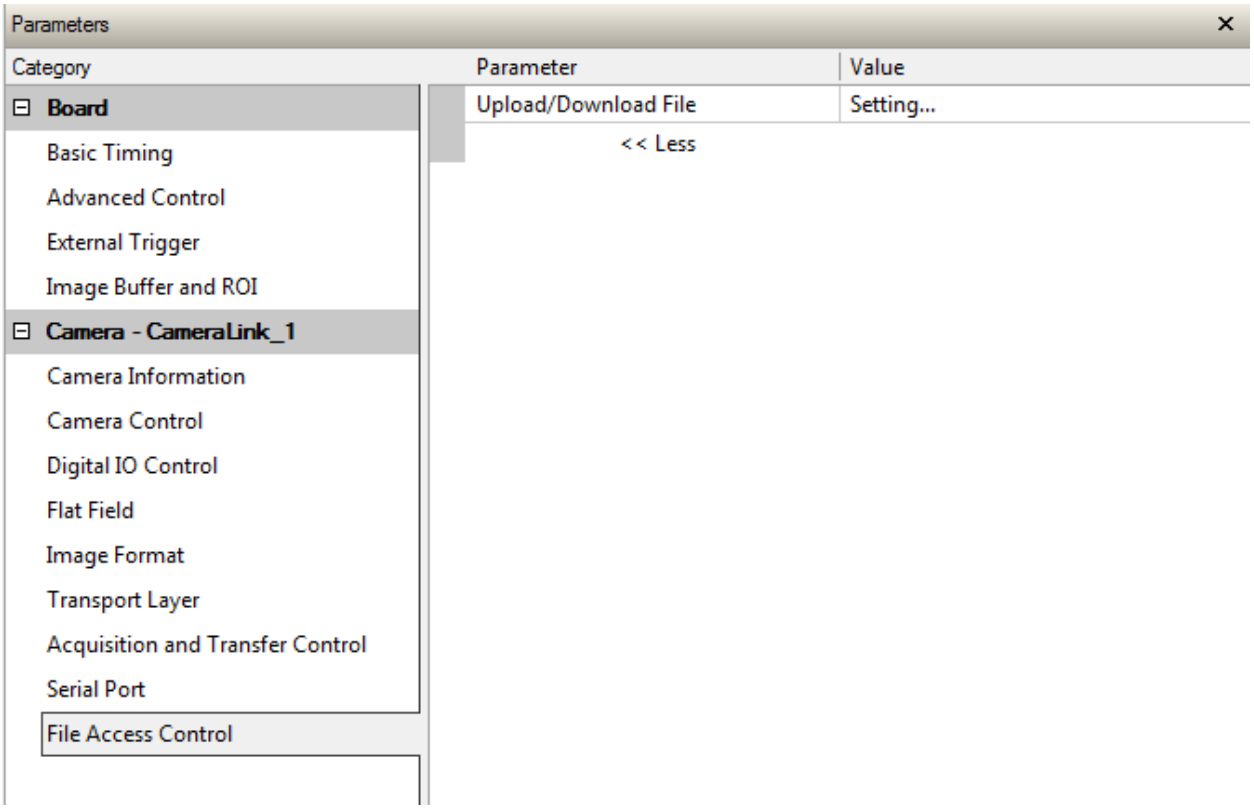
The Device Version number represents the camera software functional group, not a firmware revision number.

Display Name	Feature	Description	View
Baud Rate	DeviceSerialPortBaudRate	Sets the baud rate used by the selected device's serial port. Available baud rates are device-specific.	1.00 Beginner DFNC
Baud 9600	Baud 9600	Baud rate is 9600	
Baud 19200	Baud 19200	Baud rate is 19200	
Baud 57600	Baud 57600	Baud rate is 57600	
Baud 115200	Baud 115200	Baud rate is 115200	
Baud 230400	Baud 230400	Baud rate is 230400	
Baud 460800	Baud 460800	Baud rate is 460800	
Baud 921600	Baud 921600	Baud rate is 921600	

Display Name	Feature	Description	View
Serial Port Parity	deviceSerialPortParity	Sets the parity checking type on the selected serial port.(RO)	1.00 Beginner
None	None	Parity checking is disabled	DFNC
Data Size	deviceSerialPortDataSize	Sets the bits per character (bpc) to use (RO).	1.00 Beginner
Eight Bits	bpc8	Use 8 bits per character	DFNC
Stop Bits	deviceSerialPortNumberOfStopBits	Sets the number of stop bits to use.	1.00 Beginner
Stopbits1	Stopbits1	Use 1 stop bit	DFNC

File Access Control Category

The File Access control in CamExpert allows the user to quickly upload various data files to the connected P4. The supported data files are for P4 firmware updates, Flat Field coefficients. LUT data tables, and a custom image for use as an internal test pattern.
Features listed in the description table but tagged as *Invisible* are usually for Teledyne DALSA or third party software usage—not typically needed by end user applications.



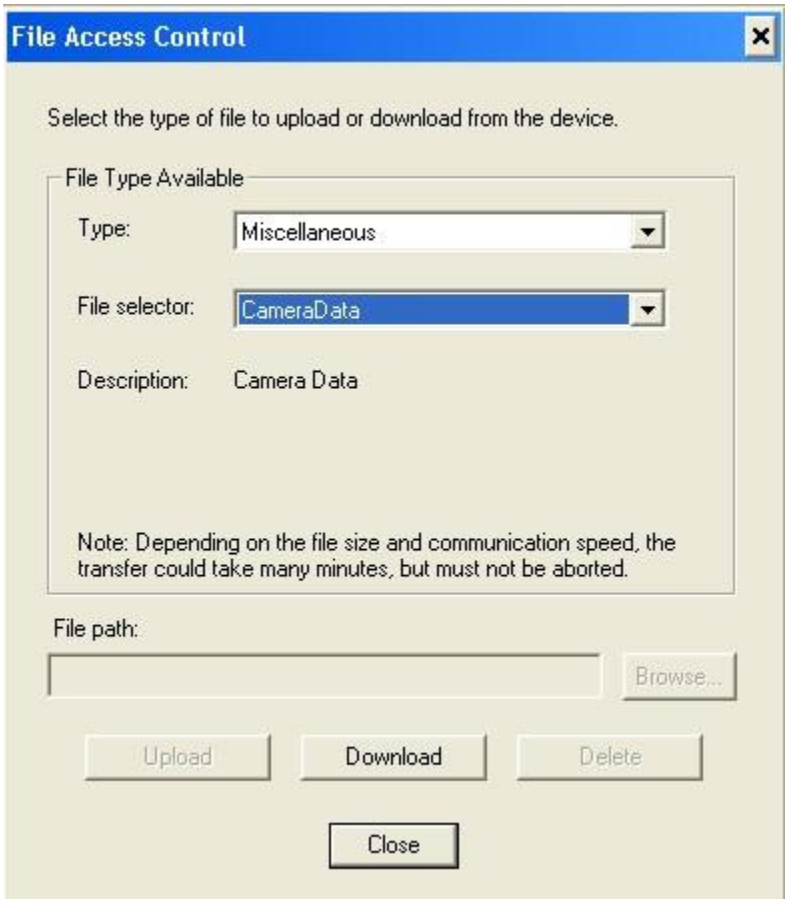
File Access Control Feature Descriptions

Display Name	Feature	Description	View
File Selector	FileSelector	Selects the file to access. The file types which are accessible are device-dependent.	1.00 Beginner
FPGA Code	Firmware1	Upload new FPGA to the camera which will execute on the next camera reboot cycle.	DFNC
Micro Code		Upload new micro codeto the camera which will execute on the next camera reboot cycle.	
CCI		Upload new CCI to the camera which will execute on the next camera reboot cycle.	
XML		Upload new XML to the camera which will execute on the next camera reboot cycle.	
User Set		Use UserSetSelector to specify which user set to access.	
Factory FlatField coefficients		Use UserSetSelector to specify which user flatfield to access.	
User FPN		Use UserSetSelector to specify which user FPN to access.	
CameraData		Download camera information and send for customer support.	
File Operation Selector	FileOperationSelector	Selects the target operation for the selected file in the device. This operation is executed when the File Operation Execute feature is called.	1.00 Guru
Open	Open	Select the Open operation - executed by FileOperationExecute.	
Close	Close	Select the Close operation - executed by FileOperationExecute.	
Read	Read	Select the Read operation - executed by FileOperationExecute.	
Write	Write	Select the Write operation - executed by FileOperationExecute.	
Delete	Delete	Select the Delete operation - executed by FileOperationExecute.	
File Operation Execute	FileOperationExecute	Executes the operation selected by File Operation Selector on the selected file.	1.00 Guru
File Open Mode	FileOpenMode	Selects the access mode used to open a file on the device.	1.00 Guru
Read	Read	Select READ only open mode	
Write	Write	Select WRITE only open mode	
File Access Buffer	FileAccessBuffer	Defines the intermediate access buffer that allows the exchange of data between the device file storage and the application.	1.00 Guru
File Access Offset	FileAccessOffset	Controls the mapping offset between the device file storage and the file access buffer.	1.00 Guru
File Access Length	FileAccessLength	Controls the mapping length between the device file storage and the file access buffer.	1.00 Guru
File Operation Status	FileOperationStatus	Displays the file operation execution status. (RO).	1.00 Guru

Display Name	Feature	Description	View
Success	Success	The last file operation has completed successfully.	
Failure	Failure	The last file operation has completed unsuccessfully for an unknown reason.	
File Unavailable	FileUnavailable	The last file operation has completed unsuccessfully because the file is currently unavailable.	
File Invalid	FileInvalid	The last file operation has completed unsuccessfully because the selected file in not present in this camera model.	
File Operation Result	FileOperationResult	Displays the file operation result. For Read or Write operations, the number of successfully read/written bytes is returned. (RO)	1.00 Guru
File Size	FileSize	Represents the size of the selected file in bytes.	1.00 Guru

File Access via the CamExpert Tool

1. Click on the "Setting…" button to show the file selection menu.



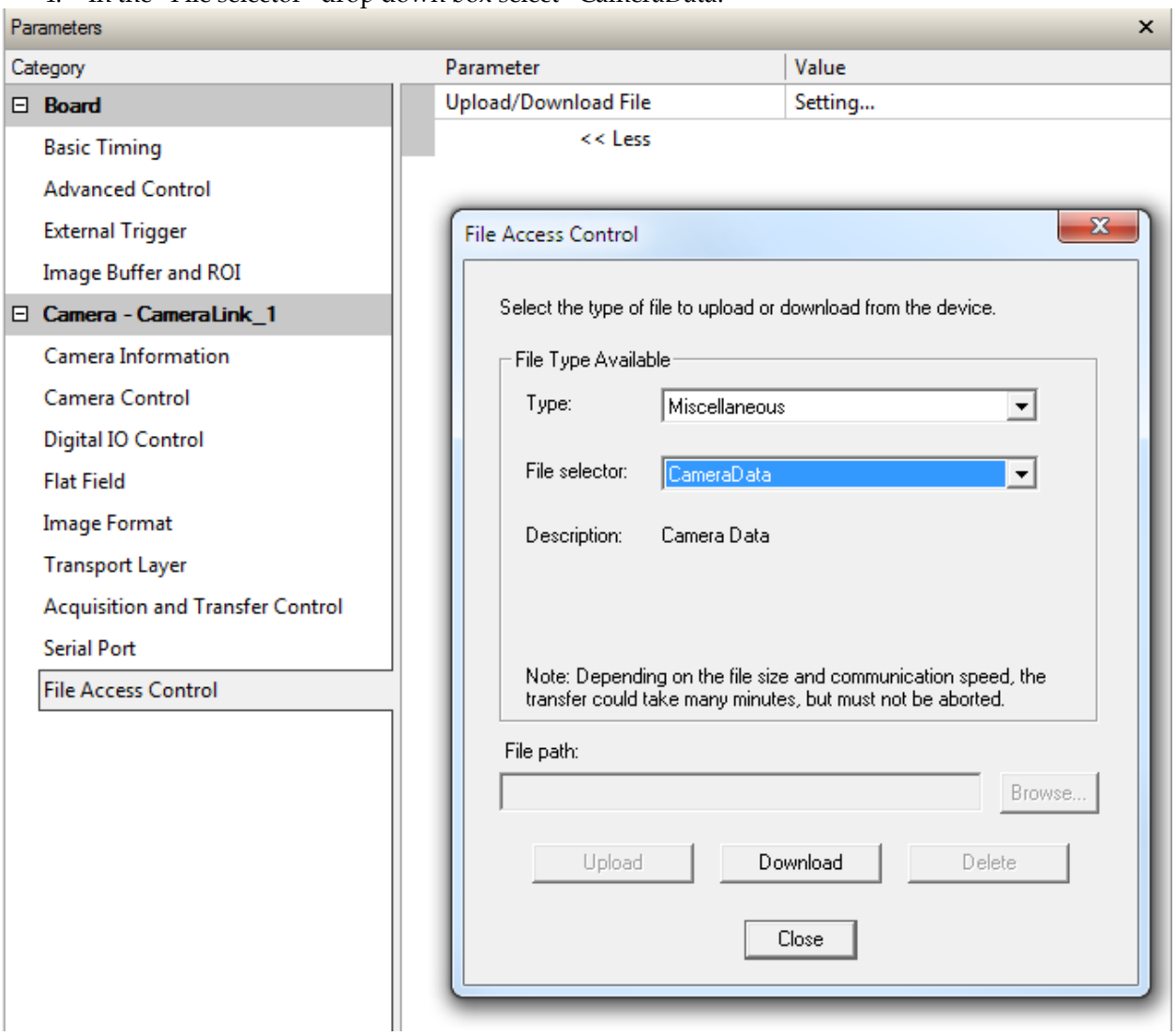
2. From the Type drop menu, select the file type that will be uploaded to the camera.
3. From the File Selector drop menu, select the camera memory location for the uploaded data. This menu presents only the applicable data locations for the selected file type.

4. Click the Browse button to open a typical Windows Explorer window.
5. Select the specific file from the system drive or from a network location.
6. Click the Upload button to execute the file transfer to the camera.
7. Note that firmware changes require a device reset command from the Camera Information Controls and, additionally, CamExpert should be shutdown and restarted following a reset.

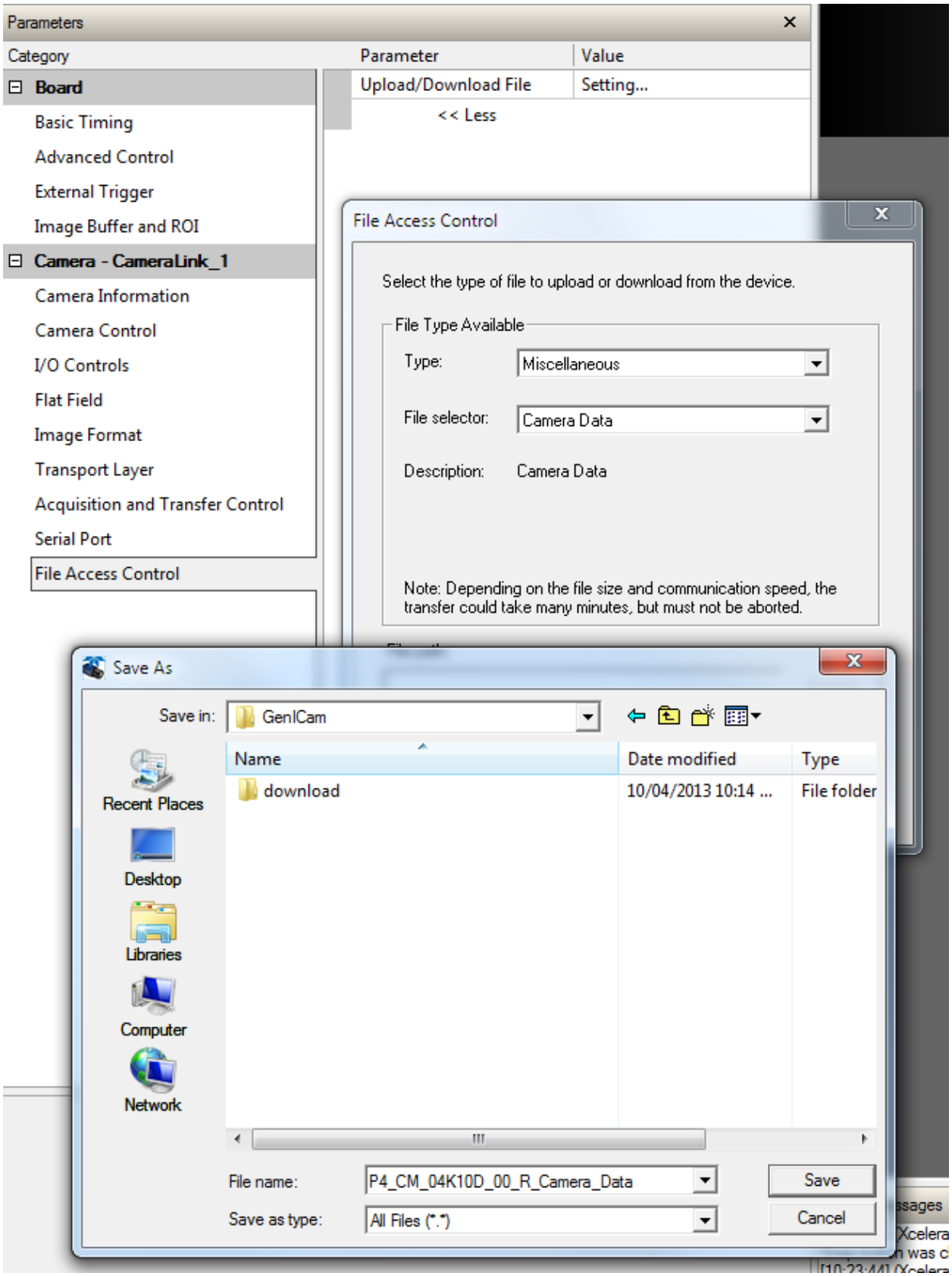
Download a List of Camera Parameters

For diagnostic purposes you may want to download a list of all the parameters and values associated with the camera.

1. Go to File Access Control
2. Click on Settings
3. In the "Type" drop down box select "Miscellaneous."
4. In the "File selector" drop down box select "CameraData."



5. Hit "Download"
6. Save the text file and send the file to Teledyne DALSA customer support.


Parameters
Category
Parameter
Value
Board
Upload/Download File
Setting...
<< Less
Basic Timing
Advanced Control
External Trigger
Image Buffer and ROI
Camera - CameraLink_1
Camera Information
Camera Control
I/O Controls
Flat Field
Image Format
Transport Layer
Acquisition and Transfer Control
Serial Port
File Access Control
File Access Control
Select the type of file to upload or download from the device.
File Type Available
Type:
Miscellaneous
File selector:
Camera Data
Description:
Camera Data
Note: Depending on the file size and communication speed, the transfer could take many minutes, but must not be aborted.
Save As
Save in:
GenICam
Name
Date modified
Type
download
10/04/2013 10:14 ...
File folder
Recent Places
Desktop
Libraries
Computer
Network
File name:
P4_CM_04K10D_00_R_Camera_Data
Save as type:
All Files (*.*)
Save
Cancel

Appendix B: ASCII Commands

The following commands can be used to control the Teledyne DALSA Piranha4 cameras.

Accessing the Three Letter Commands (TLC)

To access the TLC an ASCII-based communications interface application, such as HyperTerminal.

Additionally it is possible to use the functions of `clserxxx.dll` or `clallserial.dll` as defined in the Camera Link Specification.

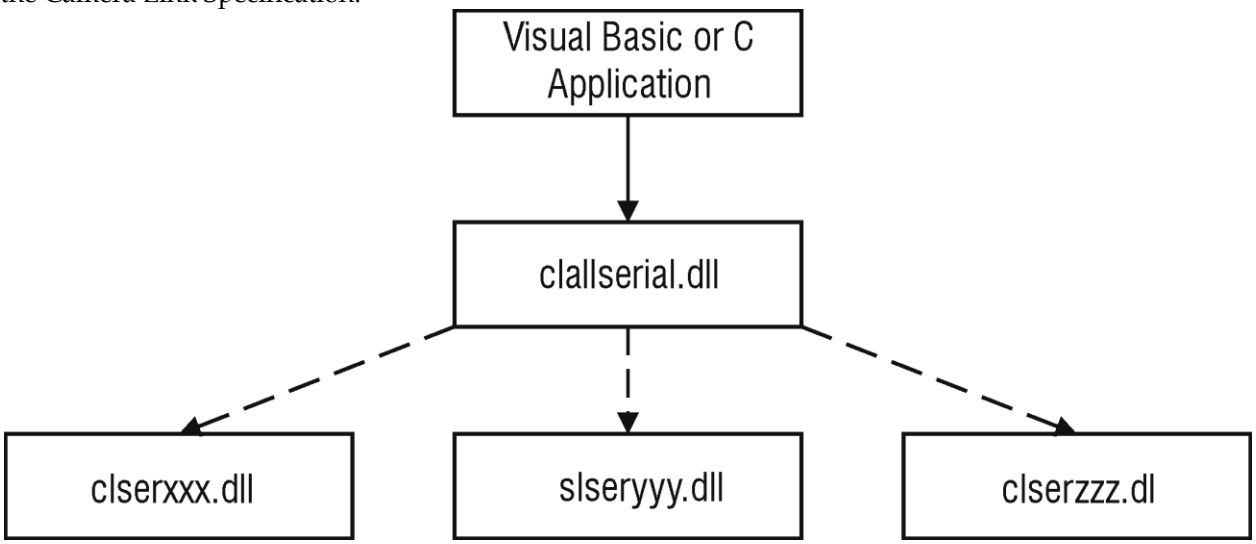


Figure 26: Serial DLL hierarchy as mentioned in the Camera Link Specification

1. Cycle power to the camera: by either a) issuing the reset camera command (rc), or b) powering the camera OFF and then ON.
2. Load the ASCII interface using:
   - 9600 baud
   - 8 data bits
   - no parity
   - 1 stop bit
   - no flow control
   - local echo
   - (carriage return / linefeed)
3. Wait for a stable status LED color (green or red) before proceeding. Note that all entries in HyperTerminal will be ignored until a stable LED color is obtained.
4. In case of HyperTerminal, press the <ESC> key.
5. Once <ESC> has been entered the help screen appears.

Notes on Using Alternatives to HyperTerminal

- If you are using interfaces other than HyperTerminal, the ASCII character, ESC, is decimal 27 and needs to be issued. From the command line insert ESC by using ALT+2+7 of the activated Num-Pad. In some cases this needs to be followed by a carriage return or a linefeed to send this to the camera.
- In ASCII the ESC character may look like this: "←".

ASCII to GenCP

To switch from the ASCII-command interface to the GenCP interface, the camera must be either reset (RC) or the power must be cycled. Note that GenCP and ASCII commands cannot be accessed simultaneously.

Note that the HyperTerminal application is not available on the Windows 7 OS.

Alternatives to HyperTerminal
The following alternative ASCII-interfaces have been tested and shown to work with this camera: PuTTY and TeraTerm. Note that PuTTY does not have Xmodem capability while TeraTerm does. Xmoden is required to update code in the camera.

TeraTerm http://logmett.com/index.php?/download/tera-term-473-freeware.html
PuTTY http://putty.en.softonic.com/

The camera responds to a simple ASCII-based protocol. A carriage return <CR> ends each command.

Example: to return the current detector settings

gcp <CR>

A complete list of the available detector commands, their format and parameters can be displayed by sending the help (**h**) command.

Port Configuration

Baud:	9,600
Bits:	8
Parity:	None
Stop bits:	1
Flow Control:	None

Echo typed characters locally.

Rules

- The interface is not case sensitive
- One command and argument(s) per line
- To enter a floating point number prefix it with a "F" – for example "ssg 0 f1.5"
- Error codes returned are the same as the GenICam™ interface – see Diagnostics | Error Codes
- Follow each command with the carriage return character – 0x0D

Disabling the Esc Key for Direct Access to ASCII Commands

By default the Esc key is enabled and an Esc key sequence has to be issued in order to access the ASCII commands. Using the DEK 1 command the need to issue an Esc key is disabled and access to the ASCII commands are available immediately upon camera boot up. Note: access to GENCP is no longer available with the Esc key disabled unless a DEK 0 command is issued and the camera re-booted.

Commands

Full Name	Calibrate User FPN	
Mnemonic	CCF	
Argument(s)	# of lines to average	• 2048 • 4096
Description	Calibrate user FPN dark flat field coefficients	

Full Name	Camera Link Speed	
Mnemonic	CLS	
Argument(s)	Frequency	0. 85 MHz 1. 66 MHz
Description	Camera Link clock frequency	

Full Name	Camera Link Mode	
Mnemonic	CLM	
Argument(s)	Mode	0. Base 1. Medium 2. Full 3. Deca (4K only)
Description	Camera Link Mode	

Full Name	Calibrate Flatfield	
Mnemonic	CPA	
Argument(s)	Algorithm	0. Basic 1. Low-pass Filter
	# of lines to average	• 2048 • 4096
	Target	0 to 4095 DN in 12 bit mode 0 to 1023 DN in 10 bit mode 0 to 255 DN in 8 bit mode
Description	Calibrate user PRNU flat field coefficients	
Notes	• Perform flat field calibration using the average of <# lines>. • With filter algorithm this average line is then smoothed and outlier pixels are interpolated. Use this feature if your white reference is not featureless. • Adjust pixel gain such that output will be <target>. • The target is first divided by horizontal binning factor and gain and then the offset is subtracted. Therefore the output will go to the target. • Because the PRNU can be less than 1, the target may be below the current maximum value. • Coefficients are saved and loaded with user set (e.g. USS / USL)	

Full Name	Disable Esc Key	
Mnemonic	DEK	
Argument(s)	Mode	0. Esc key is enabled 1. Esc key is disabled
Description	Allow the use of the Esc key to be disabled so that upon boot-up the camera will directly enter the ASCII command mode. With the Esc key disabled the GENCP cannot be accessed.	
Notes	To access the GenCP, you have to first issue the DEK 0 command in order to enable the ESC key. Then reboot the camera.	

Full Name	Device Scan Type	
Mnemonic	DST	
Argument(s)	Mode	0. Line Scan 1. Area Scan
Description	Use this command to switch between Area and Single Line modes.	
Notes	• STG must equal 1 to enter the area mode DST = 1	

Full Name	Flatfield Mode	
Mnemonic	FFM	
Argument(s)	Mode	0. Disable use of user FPN and PRNU flat field correction coefficients 1. Enable use of user FPN and PRNU flat field correction coefficients 2. Reset user FPN coefficients to zero and user PRNU coefficients to one 3. Scan direction controlled user set loading
Description	Set flat field mode	
Notes		

Full Name	Set Flatfield Scan Direction Reverse Set	
Mnemonic	FRS	
Argument(s)	User Set Number	1 to 8
Description	Set scan direction controlled reverse set	
Notes		

Full Name	Display Camera Configuration
Mnemonic	GCP
Argument(s)	
Description	Display current value of camera configuration parameters
Notes	USER>gcp Model P4_CM_02K10D_00_R Microcode 03-081-20296-96 CCI 03-110-20294-96 FPGA 03-056-20470-97 Serial # S1050616 BiST: Good DefaultSet 0 Ext Trig Off Line Rate 10000 [Hz] Meas L.R. 10000 [Hz] Max L.R. 19607 [Hz] Exp. Mode Timed Multi Exp. Mode Off Exp. Time[0] 50000 [ns] Meas E.T.[0] 50000 [ns] Max E.T. 99000 [ns] Test Pat. 0:Off Direction Internal, Forward TDI Stages 1 Vert. Bin 1 Hor. Bin 1 Flat Field Off Offset 0 System Gain 1.00 Mirror Off AOI Mode: Off Scan Type Line Scan CL Speed 85MHz CL Config Full Pixel Fmt 8 bits CPA ROI 1-2048

Full Name	Get Value
Mnemonic	GET
Argument(s)	<'parameter>
Description	The "get" command displays the current value(s) of the feature specified in the string parameter. Note that the parameter is preceded by a single quote "'". Using this command will be easier for control software than parsing the output from the "gcp" command.
Notes	

Full Name	Help
Mnemonic	H
Argument(s)	
Description	Display list of three letter commands (2K help screen shown)
Notes	USER>h P4 (03-081-20296-96): Command Line Interpreter Jul 16 2013, 07:49:58 ccf - Calibrate User FPN <2048|4096> cls - Camera Link Speed <0 - 85MHz, 1 - 66MHz> clm - Camera Link Mode <0:Base 1:Med 2:Full> cpa - Calibrate Flatfield <0:basic 1:filter><2048|4096><DN target> dek - disESC esc key <0/1> dst - Device Scan Type <0 - Line Scan, 1 - Area Scan> ffm - Flat Field Mode <0:Off 1:On 2:Initialiaze 3:Scan direction controlled> frs - Set Flatfield Scan Direction Reverse Set <set 1-8> gcp - Display Camera Configuration get - Get value '<string> h - Help lpc - Load Pixel Coefficients <set 0-8> rc - Reset Camera roi - Set Flatfield ROI <1st pixel> <last pixel> rpc - Reset Flatfield Coefficients sac - Set AOI Count <value 1-4> sad - Set AOI Selector, Offset and Width <selector 1-AOI Count> <1st pixel> <width >= 40> sam - Set AOI Mode <1-enable, 0-disable> sbh - Horizontal Binning <1|2> sbr - Set Baud Rate <9600|57600|115200|230400|460800|921600> sbv - Vertical Binning <1|2> scd - Direction <0:Fwd, 1:Rev 2:Ext> sem - Exposure Mode <0:Int 1:Ext> ses - Set Exposure Selector <0:All, 1: Bottom, 2: Top> set - Exposure Time <ns> sme - Set Multi Exposure mode <0:Off 1:On> smm - Mirroring <0:Off 1:On> spf - Pixel Format <0:8 bits 1:10 bits 2:12 bits> ssb - Offset <DN> ssf - Internal Line Rate <Hz> ssg - Gain <0:System 1:Bottom Line 2:Top Line> f<gain> stg - TDI Stages <1|2> stm - External Trigger <0:Off 1:On> svm - Test Pattern <1, 3-6> usd - Default User Set <0-8> usl - Load User Set <0-8> uss - Save User Set <1-8> vt - Temperature vv - Input Voltage

Full Name	Load Pixel Coefficients	
Mnemonic	LPC	
Argument(s)	Set selector	0. Factory set 1-8. User sets
Description	Load user set	
Notes	• Loads FPN coefficients and PRNU coefficients from a user set (only coefficeints, no other camera parameters)	

Full Name	Reset Camera
Mnemonic	RC
Argument(s)	
Description	Resets the camera to the saved user default settings. These settings are saved using the usd command.
Notes	The micro-controller reboots: • Load any file updates • Clear over temperature condition • Perform start up camera tests (BiST) • Load FPGA code • Configure FPGA and sensor. • Load default user set • Baud rate set to 9600

Full Name	Set Flatfield ROI	
Mnemonic	ROI	
Argument(s)	First pixel	1 to 2048 (2K) 1 to 4096 (4K)
	Last pixel	1 to 2048 (2K) 1 to 4096 (4K)
Description	Flat field region of interest	
Notes	• Specifies the pixels that CCF and CPA will calibrate o Pixel coefficients outside this region are not changed • Last pixel must be greater than or equal to first pixel	

Full Name	Reset Flatfield Coefficients
Mnemonic	RPC
Argument(s)	
Description	Reset all user FPN values to zero and all user PRNU coefficients to one
Notes	

Full Name	**Set AOI Count**	
Mnemonic	**SAC**	
Argument(s)	Number of AOI's	1 to 4
Description	Set AOI Counter	
Notes		

Full Name	**Set AOI Selector**	
Mnemonic	**SAD**	
Argument(s)	Selector	1 to 4
	Offset	1 to AOI Count – any pixel can be starting pixel
	Width	No less than 40 pixels
Description	Define an AOI	
Notes	• Must not overlap with an already existing AOI	

Full Name	**Set AOI Mode**	
Mnemonic	**SAM**	
Argument(s)	Mode	0. Off / Disable 1. Active / Enable
Description	Set AOI mode	
Notes		

Full Name	**Set Binning Horizontal**	
Mnemonic	**SBH**	
Argument(s)	Binning	1. Single pixel 2. Binning of 2 pixels
Description	Set horizontal binning	
Notes	• Available in all modes: single line, TDI and Area	

Full Name	**Set Baud Rate**	
Mnemonic	**SBR**	
Argument(s)	Baud rate	9600 57600 115200 230400* 460800* 921600*
Description	Set baud rate	
Notes	• Send command and then change speed of HyperTerminal • A Px8 or equivalent frame grabber is required in order to achieve these baud rates.	

Full Name	**Set Binning Vertical**	
Mnemonic	**SBV**	
Argument(s)		1. Single pixel 2. Binning of 2 pixels
Description	Set vertical binning	
Notes	• Must be in Single line mode (stg 1) • Must be in Line scan mode (dst 0)	

Full Name	**Direction**	
Mnemonic	**SCD**	
Argument(s)	Direction	0. Forward 1. Reverse (not available in single line mode) 2. External – controlled by CC3 signal (not available in single line mode)
Description	Set sensor scan direction	
Notes		

Full Name	**Set Exposure Selector**	
Mnemonic	**SES**	
Argument(s)	Mode	0. All 1. Bottom 2. Top
Description	Set exposure selector- when in multi exposure mode (see SME command) the exposure time for the top and bottom lines can be set independently	
Notes	• When not in multiple exposure mode "All" is only selection	

Full Name	**Exposure Mode**	
Mnemonic	**SEM**	
Argument(s)	Mode	0. Internal ("Timed") 1. External ("PulseWidth")
Description	Set exposure time mode	
Notes	• In internal mode the exposure time is controlled by the SET command • In external mode the sensor is exposed while CC1 signal is high • External mode is only available when the trigger mode is also external (STM 1) • SEM 1 overrides internally generated independent exposure times • When CC1 signal falls line is read	

Full Name	Exposure Time	
Mnemonic	SET	
Argument(s)	Exposure time	1, 000 to 3, 000, 000 [ns]
Description	Set internal exposure time in nanoseconds – 25 ns resolution	
Notes	• Line time > (Exposure time + 1,500 ns)	

Full Name	Set Multi-Exposure (2K only)	
Mnemonic	SME	
Argument(s)	Mode	0. Off 1. Multi-Exposure On
Description	Set multi-exposure mode allowing each line to have independent exposure times and gains.	
Notes		

Full Name	Mirroring	
Mnemonic	SMM	
Argument(s)	Mode	0. Off 1. Image is flipped on the vertical axis
Description	Set mirroring mode	
Notes		

Full Name	Pixel Format	
Mnemonic	SPF	
Argument(s)	Selector	0. 8 bits 1. 10 bits 2. 12 bits (only available with Base or Medium Camera Link configurations)
Description	Set pixel format	
Notes		

Full Name	Offset		
Mnemonic	SSB		
Argument(s)	Offset	8 bit 10-bit 12-bit	-32 to 31 -128 to 127 -512 to 511
Description	Set contrast offset – single value added to all pixels after PRNU/flat field coefficients (before gain).		
Notes	• Range changes depending on pixel format (SPF)		

Full Name	**Internal Line Rate**	
Mnemonic	**SSF**	
Argument(s)	Line rate	1 to 100, 000 [Hz] (TDI mode) 1 to 200, 000[Hz}] (Area mode)
Description	Set internal line rate in Hz	
Notes	• Line time > (Exposure time + 1, 000 ns)	

Full Name	**Gain**	
Mnemonic	**SSG**	
Argument(s)	Selector	0. System Gain 1. Bottom Line 2. Top Line
	Gain	1.0 to 10.0
Description	Set gain as a single value multiplied by all pixels.	
Notes	• When not in multiexposure mode System gain in only available • Floating point number: 1.0 to 10.0. • Note that gain value must be preceded by an "f" (e.g. ssg 0 f1.5)	

Full Name	**Set TDI Stages**	
Mnemonic	**STG**	
Argument(s)	Selector	
	TDI stage	1. Single line mode (lower sensitivity). 2. TDI mode (higher sensitivity)
Description		
Notes	• In single line mode the camera must be internal direction control • TDI mode: a pair of lines summed with suitable delay	

Full Name	**External Trigger**	
Mnemonic	**STM**	
Argument(s)	Mode	0. Internal 1. External
Description	Set trigger mode	
Notes	• In internal mode line rate is controlled by SSF command • In external mode readout starts on falling edge of CC1 signal and is available only when STM = 1 (external trigger on) • Exposure time equals high time of EXSYNC on signal on CC1	

Full Name	**Test Pattern**	
Mnemonic	**SVM**	
Argument(s)	Mode	0. Sensor Video 1. Ramp 2. A5 3. Each_tap_fixed 4. All_1365 5. All_1
Description	Select test pattern	
Notes	• When a test pattern is selected all digital processing (e.g. flat field, gain) is disabled – it is re-enabled when sensor video is selected	

Full Name	**Default User Set**	
Mnemonic	**USD**	
Argument(s)	Set selector	0. Factory set 1-8. User sets
Description	Select user set to load when camera is reset	
Notes	• The settings include all those listed by the GCP command plus the user FPN coefficients, and user PRNU coefficients	

Full Name	**Load User Set**	
Mnemonic	**USL**	
Argument(s)	Set selector	0. Factory set 1-8. User sets
Description	Load user set	
Notes	• Loads and makes current all the settings listed by the GCP command plus the user FPN coefficients, and user PRNU coefficients	

Full Name	**Save User Set**	
Mnemonic	**USS**	
Argument(s)	Set selector	1 to 8
Description	Save user set	
Notes	• Saves all the current settings listed by the GCP command plus the user FPN coefficients, and user PRNU coefficients	

Full Name	**Temperature**
Mnemonic	**VT**
Argument(s)	
Description	Display internal temperature in degrees Celsius
Notes	• Measured with an accuracy of ± 1.5 °C.

Full Name	Voltage
Mnemonic	VV
Argument(s)	
Description	Display supply voltage
Notes	• Measured with an accuracy ± 0.1 V.

Appendix C: Error and Warning Messages

BiST: Built in Self Test
The BiST error flags are binary flags with each bit being independent from each other. The message from the BiST should be "Good" meaning everything is functioning correctly but if a hardware failure does occur in the camera one or more these flags could be set. Any of these errors will result in the status light turning red.

Definition	BiST Flag
I2C error	1
Unable to configure fpga	10
Unable to configure fpga	100
EXT_SRAM Failure	1000
ECHO_BACK Failure	1,0000
FLASH_TIMEOUT	10,0000
FLASH_ERROR	100,0000
NO_FPGA_Code	1000,0000
NO_COMMON_SETTINGS	1,0000,0000
NO_FACTORY_SETTINGS	10,0000,0000
NO_USER_SETTINGS	100,0000,0000
NO_FLAT_FIELD Corrections	1000,0000,0000
NO MISC corrections	1,0000,0000,0000
NO_FPN Correction	10,0000,0000,0000
NO_FPN Correction	100,0000,0000,0000
NO_PRNU Correction	1000,0000,0000,0000
NO_FEED Through Correction	1,0000,0000,0000,0000
NO_LINEARITY Correction	10,0000,0000,0000,0000
SYNC_ERROR	100,0000,0000,0000,0000
OVER_TEMPERATURE	1000,0000,0000,0000,0000
SPI Failure	1,0000,0000,0000,0000,0000
NO_USER_FPN	10,0000,0000,0000,0000,0000
PLL_LOCK_FAILED	100,0000,0000,0000,0000,0000
INVALID_CCI	1000,0000,0000,0000,0000,0000
No LUT	1,0000,0000,0000,0000,0000,0000
Incompatible FPGA code	10,0000,0000,0000,0000,0000,0000

Operational Error Codes

Code	Description
0X8002	Invalid Parameter
0xC01C	CPA_TOO_MANY_OUTLIERS
0x401E	USER_FPN_CLIPPING
0x401F	FLAT_FIELD_CLIPPING

Appendix D: Quick Setup and Image Acquisition

If you are familiar with the operation of Camera Link cameras and have an understanding of imaging fundamentals, the following steps will show you how to quickly set up this camera and begin acquiring images.

1. On Power-Up

The camera has been calibrated and configured at the factory to be ready for your evaluation when first powered up. The default conditions are set as follows:

- System gain is set to the lowest value of one.
- Flat field calibration is *not* active as this feature is dependent on your light source and lens.
- Line rate and exposure time are set to for internal generation by the camera.
- Camera Link mode is set to the standard 8-bit full mode which allows operation of up to 100 kHz line rate. Set your Camera Link frame grabber up to receive the standard 8-bit full mode.

2. Communicating with the Camera

- The camera is designed to power up with a GenICam-compliant interface.
- CamExpert provides an easy-to-use GUI that can be used to set up and evaluate the camera.
- The camera also comes with Teledyne DALSA's three letter command (TLC) interface option, which can be accessed using a suitable terminal program such as HyperTerminal™.
- If you want to use the TLC interface, press the 'Esc' key while using a terminal program only after the LED indicator on the camera turns green. Note that the camera defaults to 9.6 KBaud when first powered up.
- On receiving the 'Esc' character, the camera will output a list of the available TLC commands. You can then proceed to enter TLC commands as required.
- Enter 'h' at any time to get the list of commands from the camera.
- Enter the 'gcp' command at any time to get the current setup conditions of the camera.

3. Setting Up Your Optical Configuration

Typically, the first thing you want to do is to evaluate the camera's image quality under operating conditions similar to those that you are likely to use in your application. In order to do this, take the following steps:

- The illumination, lens magnification, and focus should be set up as per you application.
- Getting the magnification right is best accomplished by setting the object-to-sensor distance. Use the formula *lens focal length x (2 + 1/magnification + magnification)* to calculate this distance. Magnification equals the sensor pixel size (10.56 µm) / (your object pixel size in um).
- The approximate position of the sensor is at the first groove on the side of the camera case from the front face of the camera.

4. Camera Timing & Control

It is easiest and quickest to evaluate the camera using the internal timing setups for line rate and exposure time.

- The camera starts up in the default configuration of camera link full, TDI mode, forward direction, 10 kHz line rate and 50 µsec exposure time.
- If this line rate is too slow for your application, you will get a compressed image in the scan direction. You can increase the line rate by using the 'ssf' command.
- You can set the exposure time using the 'set' command. Ensure that the exposure time period is not greater than the period of the line rate minus 1.0 µsec.
- The camera will indicate an error if you select an exposure time that is too long. The minimum exposure time is 4 µsec.
- Set your camera direction using the 'scd' command.

5. Acquiring an Image

You can now begin imaging. Unless you have an application employing lots of light, the image is likely to be too dark.

- Use the system gain to adjust the camera output to achieve the desired response. The system gain range is from 1x to 10x. Use the 'ssg' command.
- Once you have a suitable response, you can now focus the lens.
- The image may be darker at the edges due to lens vignetting, but this will be improved once the camera is calibrated.
- Calibration is performed using a white reference where your object is normally located.
    - Use a white material that has no texture, such as a non glossy plastic.
    - If you must use white paper, make sure it is moving during the calibration process. If you do not do this, your image will have vertical stripes.

- Calibration is easily performed using the ‘cpa’ command.
- The cpa command has 3 parameters.
    - The first parameter is a selection between:
        - ‘0’ – Per pixel FFC calibration
        - ‘1’ – A low pass FFC calibration
    - We recommend that the second option is used to correct for any image non uniformity due to the lens and setup.
    - The second parameter is the number of lines you want to average over. Use a value of 4096 to achieve the best average.
    - The third parameter is the 12-bit target value you want to achieve after calibration.
- The cpa command takes several seconds to complete. The slower the line rate, the longer it will take.
- On completion of the ‘cpa’ command, you should see an image from the camera that is flat field corrected with the lens at the target level you set.

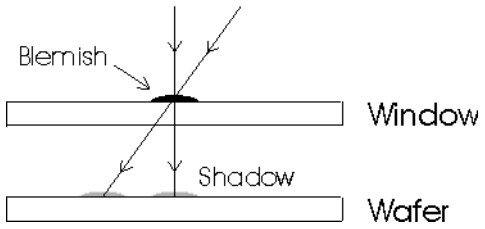
You are now ready to evaluate the image quality of the P4 camera under your operating conditions.

Appendix E: The Sensor Window

Cleaning and Protecting Against Dust, Oil, and Scratches

The sensor window is part of the optical path and should be handled like other optical components, with extreme care. Dust can obscure pixels, producing dark patches on the sensor response. Dust is most visible when the illumination is collimated. The dark patches shift position as the angle of illumination changes. Dust is normally not visible when the sensor is positioned at the exit port of an integrating sphere, where the illumination is diffuse. Dust can normally be removed by blowing the window surface using an ionized air gun. Oil is usually introduced during handling. Touching the surface of the window barehanded will leave oily residues. Using rubber fingercots and rubber gloves can prevent contamination. However, the friction between rubber and the window may produce electrostatic charge that may damage the sensor. To avoid ESD damage and to avoid introducing oily residues, avoid touching the sensor. Scratches diffract incident illumination. When exposed to uniform illumination, a sensor with a scratched window will normally have brighter pixels adjacent to darker pixels. The location of these pixels will change with the angle of illumination.

An important note on window blemishes:
When flat field correction is performed, window cleanliness is paramount. The figure below shows an example of what can happen if a blemish is present on the sensor window when flat field correction is performed. The blemish will cast a shadow on the wafer. FFC will compensate for this shadow by increasing the gain. Essentially FFC will create a white spot to compensate for the dark spot (shadow). As long as the angle of the incident light remains unchanged then FFC works well. However when the angle of incidence changes significantly (i.e. when a lens is added) then the shadow will shift and FFC will makes things worse by not correcting the new shadow (dark spot) and overcorrecting where the shadow used to be (white spot). While the dark spot can be potentially cleaned, the white spot is an FFC artifact that can only be corrected by another FFC calibration.



Cleaning the Sensor Window

Recommended Equipment

- Glass cleaning station with microscope within clean room.
- 3M ionized air gun 980 (http://solutions.3mcanada.ca/wps/portal/3M/en_CA/WW2/Country/)
- Ionized air flood system, foot operated.
- Swab (HUBY-340CA-003) (http://www.cleancross.net/modules/xfsection/article.php?articleid=24)
- Single drop bottle (FD-2-ESD)
- E2 (Eclipse optic cleaning system (www.photosol.com)

Procedure

- Use localized ionized air flow on to the glass during sensor cleaning.
- Blow off mobile contamination using an ionized air gun.
- Place the sensor under the microscope at a magnification of 5x to determine the location of any remaining contamination.
- Clean the contamination on the sensor using one drop of E2 on a swab.
- Wipe the swab from left to right (or right to left but only in one direction). Do this in an overlapping pattern, turning the swab after the first wipe and with each subsequent wipe. Avoid swiping back and forth with the same swab in order to ensure that particles are removed and not simply transferred to a new location on the sensor window. This procedure requires you to use multiple swabs.
- Discard the swab after both sides of the swab have been used once.
- Repeat until there is no visible contamination present.

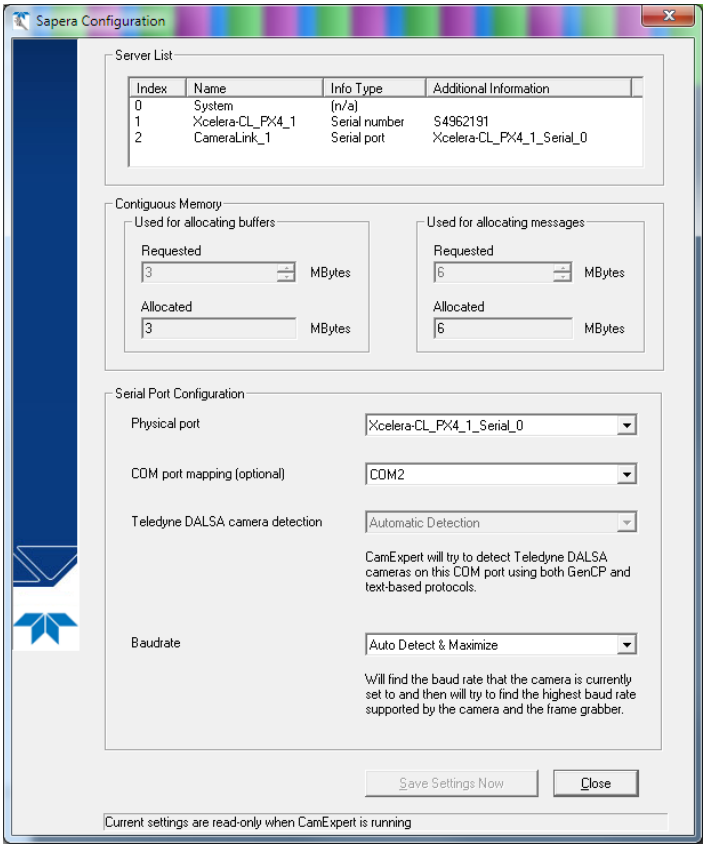
Appendix F: Camera, Frame Grabber Communication

Setting Up Communication between the Camera and the Frame Grabber

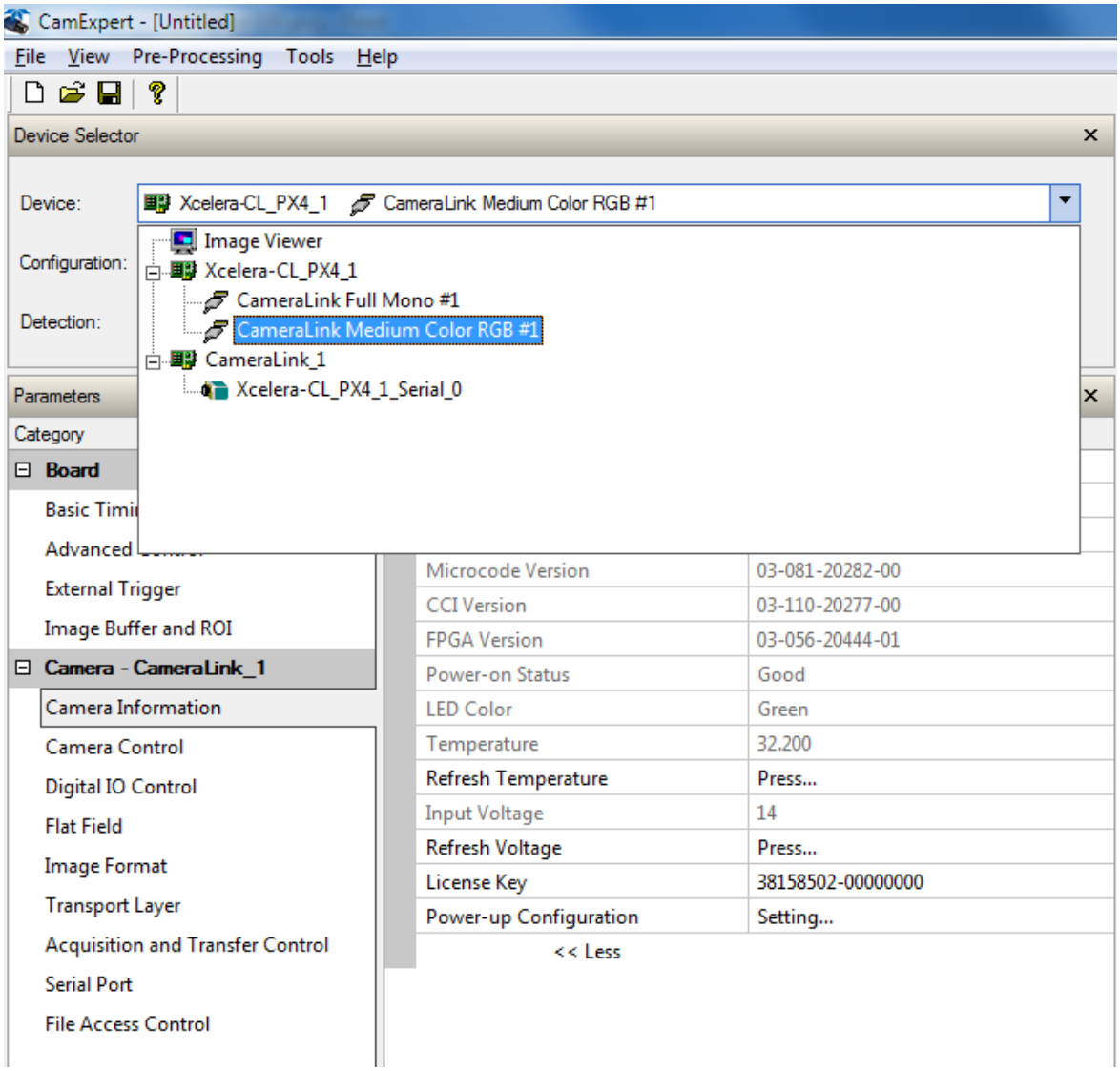
Teledyne DALSA Camera Link cameras support the GenCP Camera Link standards.

To configure Teledyne DALSA GenCP Camera Link Cameras:

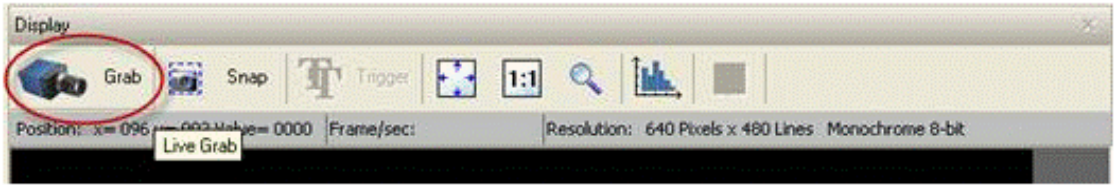
1. Install the Teledyne DALSA frame grabber in the host computer; refer to the hardware installation manual.
2. Install Sapera LT and the Teledyne DALSA frame grabber driver.
3. Connect the camera to the frame grabber; refer to the camera installation manual.
4. Power up the camera and wait until the status LED is solid green.
5. Run the Sapera Configuration utility and select the frame grabber serial port connected to the camera. Set **Teledyne DALSA camera detection** to **Automatic Detection** and **Baudrate** to **Auto Detect & Maximize**.
6. If the camera will be configured using three-letter text commands via a terminal program, such as HyperTerminal, then set **COM port mapping (optional)** to an available COM port (e.g. COM2).



7. Start the CamExpert application. In the **Device** tab, select **CameraLink Medium Color RGB #1**.



8. Modify the camera and frame grabber parameter settings as required. At present, when using GenCP cameras, the camera and frame grabber parameters must be adjusted separately. Test the image acquisition by clicking the **Grab** button.



9. Save the frame grabber configuration to a new *.ccf file.

EMC Declaration of Conformity

We, TELEDYNE DALSA
605 McMurray Road
Waterloo, Ontario
CANADA N2V 2E9

Declare under sole responsibility that the cameras:
Brand Name: Piranha4

Models: P4-CM-04K10D-00-R and P4-CM-02K10D-00-R

Which are components to be integrated into larger systems, were evaluated according to the CE Mark, FCC Part 15, VCCI, Israel, Korea, and Industry Canada ICES-003 Evaluation and satisfy the requirements of the following standards:

EN 55022 (2010)
EN 55011 (2009)
EN 61326-1 (2006)
EN 55024 (2010)
CISPR-22
ICES-003
CISPR-11
FCC Part 15

Place of issue: Waterloo, Ontario, Canada

Date of Issue: February 4, 2013

Hank Helmond
Director of Quality, TELEDYNE DALSA Corp.

Revision History

Revision Number	Change Description	Revision Date
00	Initial release.	April 17, 2013
01	- Updated CamExpert screenshots. - Removed 7 µm pixel option. - Revised AOI calculation table. -Device Scan Type feature added to Camera Controls description. -Revised Full and Deca timing diagrams.	May 13, 2013
02	- 2k power dissipation value added: < 8.25 W. - Revised responsivity and QE graphs. - 2k line rates added to Line Rates table. -Device User ID feature described. - TDI Stages, Multi-Exposure Mode, and Exposure Time selector features described. -Disabling ESC key for direct access to ASCII commands option described.	November 22, 2013

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